Established by BENJAMIN SILLIMAN in 1818.

PUBLIC LIBRARY OF THE CITY OF BOSTON

THE AMERICAN JOURNAL OF SCIENCE.

EDITOR: EDWARD S. DANA.

ASSOCIATE EDITORS

PROFESSORS GEORGE L. GOODALE, JOHN TROWBRIDGE, W. G. FARLOW AND WM. M. DAVIS, OF CAMBRIDGE,

PROFESSORS ADDISON E. VERRILL, HORACE L. WELLS, L. V. PIRSSON AND H. E. GREGORY, OF NEW HAVEN,

PROFESSOR GEORGE F. BARKER, OF PHILADELPHIA,
PROFESSOR HENRY S. WILLIAMS, OF ITHACA,
PROFESSOR JOSEPH S. AMES, OF BALTIMORE,
MR. J. S. DILLER, OF WASHINGTON.

FOURTH SERIES.

VOL. XIX—[WHOLE NUMBER, CLXIX.]

No. 111.—MARCH, 1905.

NEW HAVEN, CONNECTICUT.

1905

THE TUTTLE, MOREHOUSE & TAYLOR CO., PRINTERS, 123 TEMPLE STREET.

Published monthly. Six dollars per year, in advance. $6.40 to countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks (preferably on New York banks).

RADIUM

AND

RADIO-ACTIVE MINERALS.

Commercial Quantities or Specimens.

We are making a specialty of the various rare minerals containing Radium and other radio-active elements.

Uraninite (Pitchblende). The finest quality from the Colorado mines.

Carnotite, Colorado. All grades from the muddy looking sandstone to the pure mineral of the brightest canary-yellow color.

Thorianite, Ceylon. Thorium, Cerium, Uranium and Lead Oxides. Recently described by Sir Wm. Ramsay. Modified cubes and twins, about 3 to 5^{mm} diameter. Smaller crystals for analysis.

Curie Collection of Radio-Active Minerals. Consists of following 24 specimens of the species investigated by Mme. Curie:—Uraninite (4), Cleveite, Torbernite (Chalcolite), Autunite, Thorite (2), Orangite (2), Monazite, Xenotime, Aeschynite, Fergusonite (2), Samarskite, Columbite (3), Tantalite (2), Carnotite (2). In glass-stoppered bottles fitted in mahogany cabinet.

Fluorescent Minerals. Choice examples of Willemite, Hyalite, Selenite, Aragonite, Colemanite.

COMPLETE MINERAL CATALOG

Contains numerous valuable lists and tables with prices. Illustrated. 216 pp., paper, 25 cents.

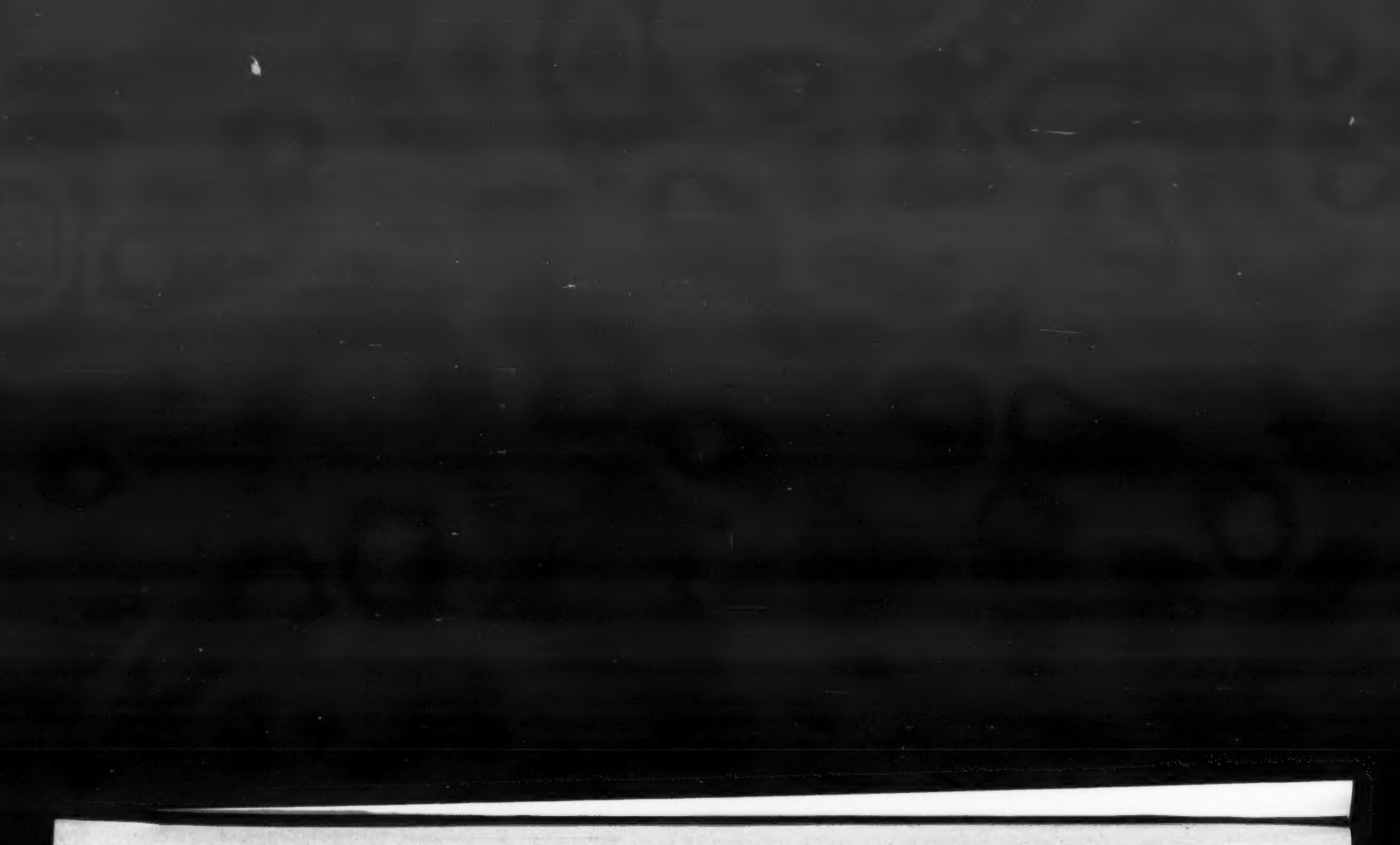
Free Catalog mailed on request, giving lists and prices of systematic collections and of individual specimens.

FOOTE MINERAL CO.,

MINERALS FOR COMMERCIAL AND EDUCATIONAL PURPOSES.

1317 Arch Street, Philadelphia.

Established 1876, by Dr. A. E. Foote.



THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

Art. XIV.—*On the Optical Constants of the Human Eye for different Colors;* by Charles S. Hastings.

A complete determination of the optical constants of the human eye for all conditions of accommodation and for all colors is yet wanting in the literature of physiological optics. Indeed, the only addition to the knowledge possessed by Helmholtz and published in his famous Physiologische Optik nearly forty years ago, consists in a slight change in his assumptions as to the dimensions of the schematic eye and a calculation of its cardinal points when accommodated for a near object.*

A necessary use for a larger knowledge recalled to my mind a series of observations made several years ago for a different purpose, but which would clearly yield the required information. These observations are contained in the following table, in which the first column contains the Fraunhofer line which defines the kind of light observed; the columns headed N and F, respectively, the nearest and farthest distances, in inches, at which I could see distinctly the spectral line; the column under $-c$ is the mean of the reciprocals of N and F, and the last column the difference of these reciprocals.

Line	N	1/N	F	1/F	$-c$	1/A
A	15·75	·06349	18·00	·05556	·05952	·00793
D	12·60	·07937	13·80	·07246	·07592	·00691
F	10·40	·09615	11·25	·08889	·09252	·00726
G	8·60	·11628	9·50	·10526	·11072	·01102
H.K	7·25	·13793	8·50	·11765	·12779	[·02028]

* It should be noted that W. Einthoven computed the constants for two different refrangibilities, namely, for that of the Fraunhofer D and F lines, for a schematic eye adjusted for great distance; but his assumption that the dispersive power is very nearly as great as that of dense flint glass makes them unavailable. A possible missprint renders two of the constants erroneous. See Pflüger Archiv. f. Physiol., lxii, 166.

The last column headed 1/A is the well known Donders constant of accommodation. This should be nearly constant for all wave-lengths of light. Neglecting the last value, which is sure to be greatly in excess on account of unavoidable errors due to fluorescence of media of the eye impairing the precision of vision in this region of the spectrum, the mean value of the accommodation constant is ·00825/1 in. With this value of the constant of accommodation and an assumed accuracy of the values of c, the calculated values of the far and near points are as follows:

	N′	F′
A	15·71	18·06
D	12·50	13·94
F	10·35	11·31
G	8·70	9·38
H.K	7·58	8·09

The errors implied in the observations of the extreme violet light are just such as we should expect from the imperfect vision in this region of the spectrum due to fluorescence. If we assume that the differences for the other wave-lengths are due to errors of observation only, we find that the probable error of a single measurement is $\pm 0{\cdot}067$ of an inch. As the measurements seem to have aimed at a precision not much greater than 0·1 of an inch, the accordance must be regarded as very satisfactory.

As to the precision with which c is determined, for it is the variation of this quantity which yields the physical constant desired, we have the following test. It is known that the media of the eye have dispersive powers not differing in kind from that of other colorless media, hence the differential refractive power of the eye ought to be expressible as a linear function of the indices of refraction of such substances, water for example. Thus, from the following data,

	$C_A - C$	$n - n_A$
A	·00000	·00000
D	·01640	·00365
F	·03300	·00788
G	·05125	·01135
H.K	·06827	·01424

I find,

$$c_A - c = (4{\cdot}50 \pm {\cdot}08)\,(n - n_A)\ 1/1\ \text{inch.}$$

In this result the observation on extreme violet light is included. The general conclusion, when the centimeter is chosen as the unit of length, may be written

$$\delta c / \delta n = 1{\cdot}77 / 1^{\text{cm}}$$

where δn indicates the variation of index of refraction of water.

The results given above must be regarded as very accurate for the myopic eye studied, but it is not quite obvious how they should be employed as a basis for estimating the dispersive power of the average human eye, which may be supposed to be accurately equivalent to the schematic eye described in Helmholtz.* It seems probable, however, that the assumption that such an eye would possess the same differential power for different wave-lengths of light will prove not far from the truth. Under these conditions, since it is known that the dispersive powers of the aqueous and vitreous humors are the same as that of water, it is possible to calculate the virtual dispersive power of the lens of the eye, and it is found that we must assume a dispersive power in the lens of the schematic eye about half way between that possessed by ordinary crown glass and by dense flint glass, or, quite accurately, that of turpentine. If it were supposed that the eye examined differed from the schematic eye only in having a thicker lens, this value would be somewhat smaller. A discussion of known facts bearing on this point will appear at the end of the article.

We are now in a position to calculate all the cardinal points of the schematic eye for all accommodations and for all wave-lengths, but as these values cannot be given as linear functions of the variables, it is more useful to arrange a sufficient number in tables so that any required value can be found by proper interpolation. As a basis of the computations I adopt, after Helmholtz, as the mean refractive index of the aqueous and vitreous humors, $n_0 = 1{\cdot}3365$, and as that of the lens, $n'_0 = 1{\cdot}4371$. Also, the radii of the cornea, the front surface of the lens, and the back surface, are, respectively, 0·728, 1·000, and 0·600 centimeters. Finally, the dispersive power of the two humors being equal to that of water, we have:

	A	B	C	D	E	F	G	H
$n-n_0$	−·00558	−·00446	−·00370	−·00183	+·00045	+·00241	+·00590	+·00900

while, to meet the measured chromatic error of the eye as determined above,

$$\delta n'/\delta n = 1{\cdot}57.$$

With these data I have computed the following tables. The values of c' in both tables are the reciprocals of the distance

* See Helmholtz, Physiologische Optik, 2te Auflage s. 140.

TABLE I.

Curvature of incident wave-surface		$c' = \cdot0000$	$c' = -\cdot0100$	$c' = -\cdot0330$	$c' = -\cdot0660$
		x	δx		
Curvature of the cornea	γ	1·2773			
Curvature of the first lens surface	γ'	1·0000	·1043	·3433	·6690
Curvature of the second lens surface	γ''	−1·6667	−·0239	−·0746	−·1520
Distance from vertex of cornea					
to first lens surface	d	·360	−·0060	−·0200	−·0400
to second lens surface	d'	·720			
to first principle focus	F_1	−1·3744	·0279	·0873	·1618
to second principle focus	F_2	2·2823	−·0316	−·0995	−·1876
to first principle point	p_1	·1753	·0021	·0063	·0105
to second principle point	p_2	·2110	·0029	·0087	·0146
to first nodal point	n_1	·6969	−·0066	−·0210	−·0404
to second nodal point	n_2	·7325	−·0057	−·0186	−·0363

of distinct vision measured from the vertex of the cornea, which is taken as the origin of abscissas. The curvature of the cornea and the position of the second vertex of the lens are invariable.

For the chromatic differences for these constants we find the following table:

TABLE II.

$\delta x/\delta n$

x	$c' = \cdot0000$	$c' = -\cdot0100$	$c' = -\cdot0330$	$c' = -\cdot0660$
F_1	+5·660	+5·593	+5·464	+5·283
F_2	−5·504	−5·448	−5·342	−5·182
p_1	+0·175	+0·167	+0·158	+0·152
p_2	+0·335	+0·335	+0·331	+0·329
n_1	−0·179	−0·190	−0·211	−0·228
n_2	−0·019	−0·022	−0·038	−0·051

With these two tables it is easy to solve all problems connected with the purely optical properties of the schematic eye. We may, for example, employ them for comparing the performance of the model with any recorded observation on real eyes. Thus Helmholtz (page 158) states that for his eye the difference of accommodation for red (C) and violet (G) light was ·0167, in the units employed in the tables, while Fraunhofer, who gave the first recorded measures involving this magnitude, found a value included between ·0154 and ·0205. The schematic eye as described in this paper demands ·0167.

After all the above calculations were concluded I found a series of observations on his own eye by Max Wolf* which might have been used as well as the ones given above. His method was to observe a small globule of mercury, strongly

* Annalen d. Physik u. Chemie, xxxiii, 1888.

illuminated by sunlight, through a prismatic ocular and find the displacement of the globule when sharp definition of the spectrum was secured at different Fraunhofer lines. These observations are by no means easy, but they were carried out with remarkable skill so that the means of four series gave, after eliminating the dispersion due to the lens of the ocular, a result of exactly the same degree of precision as my own. Professor Wolf made no other use of his results than to prove that the human eye has notably greater dispersion than the reduced eye of Listing which is supposed to be made of pure water; but a reduction of them after the method in which mine were treated, when corrected for the slight degree of hypermetropy possessed by his eye, gave $\delta n'/\delta n$ equal to 1·523. In view of this fact I should prefer 1·54 as a definitive value were so small a change really worth while. Since the last value only differs from that employed by an amount equal to the probable error attaching to it, we may, I think, accept the results given above with considerable confidence.

Yale University, January, 1905.

ART. XV. — *Notice of the Discovery of a New Dike at Ithaca, N. Y.;** by V. H. BARNETT.

THE occurrence of several dikes of igneous rock cutting the Devonian shales and sandstones near Ithaca, N. Y., was recognized as early as 1842. Vanuxem† records in his report on the 3d District, the presence of four small dikes near Ludlowville. Other small dikes, which were discovered by students and professors of Cornell University, were described in a paper by Prof. Kemp,‡ in 1891. This paper is the latest published statement, so far as the writer knows, concerning the dikes at Ithaca. According to Prof. Kemp, four dikes were then known in the vicinity of Ithaca in addition to those recorded by Vanuxem. Kemp was able to relocate but two of Vanuxem's dikes, so that the total number then known was six.

During the past season the writer, engaged as a field assistant on the U. S. Geological Survey, discovered in connection with Dr. E. M. Kindle a number of hitherto unknown dikes in the vicinity of Ithaca. Most of these dikes, like those previously known at Ithaca, are thin sheets of peridotite generally from one to five inches in width. The total number of dikes now known to the writer near Ithaca exceed twenty-five.

One of the newly discovered dikes is of such unusual size for this region as to justify a brief preliminary notice. It is exposed in a small ravine on the west side of Lake Cayuga about one mile south of Glenwood. The dike is of light greenish gray color with numerous inclusions of shale and small limestone fragments. The latter are probably derived from the Tully limestone, which is some 450 feet below the outcrop. The numerous included fragments give the mass a breccia-like appearance. The direction is nearly north and south, but the contact is irregular and clearly shown on the east side, where the shale is considerably baked. On the west side the dike passes under a mass of drift so that the total width is not known. It is, however, not less than 25 feet thick. Another dike mass, 13 feet in width, lies 150 feet to the west of the one just described and is identical with it in appearance. The latter terminates abruptly on the west along a joint plane of the shale, and passes under the drift on the east. The relations of the two masses suggest that they may represent a single dike considerably more than 100 feet in width which pinches out both north and south. In Indian Creek, about three-quarters mile south of this outcrop, is a two foot dike and in Glenwood Creek, to the north, a dike eight feet wide occurs.

Ithaca, N. Y., January 24.

* Published by permission of the Director of the U. S. Geological Survey.
† Rep. 3d Dist. N. Y. State Geological Survey, p. 169.
‡ This Journal (3), vol. xlii, pp. 410–412, 1891.

ART. XVI.—*Dumortierite;* by WALDEMAR T. SCHALLER, U. S. Geol. Survey.

THE following paper* is an excerpt of a paper on dumortierite to appear in a forthcoming bulletin of the U. S. Geol. Survey.

The description is mainly of the lavender California dumortierite and also of the Washington mineral. Several imperfect crystals—two from California, one from Arizona and three from New York—were found and some crystallographic data obtained.

The California dumortierite occurs in a dike, a few miles east of Dehesa, San Diego Co. The dike is in a disintegrated biotite granite and has a length of about 1000 feet with a thickness of from 30 to 40 feet and strikes S. 70° E., with a dip of 70° N. 20° E. The upper part of the dike is a fine-grained rock consisting of quartz and sillimanite, while the lower part is a coarse rock composed of quartz and dumortierite, the latter in radiating masses several centimeters thick. They show a transverse parting fairly well developed: the color of the mineral is lavender instead of blue; the pleochroism is from colorless to red-purple.

A number of thin sections of the dumortierite rock were prepared and studied with the following results.

Microscopically the minerals present in the lower part of the dike are seen to be dumortierite and quartz with muscovite and sillimanite in small quantities, together with accessory magnetite, titanite, rutile (?), apatite and zircon, with a number of small undetermined inclusions. The dumortierite occurs in irregular masses with ragged outline, and also in fan-shaped radiating masses sometimes of large size. Irregular broken fibrous masses also occur scattered through the slide. The quartz is allotriomorphic and is but slightly cracked. It is rather full of inclusions in places. With the exception of a little muscovite, there are no secondary minerals present.

The common form for the dumortierite is the radiated fan-like masses that vary considerably in size. When the entire piece is larger than a quadrant, parts of the black cross (seen in spherulites) are seen when the nicols are crossed. These fan-shaped pieces are probably the results of an incomplete spherulitic growth. The most perfect one consisted of but half a circle. On certain parts no radiated fibers are detectable, the (prismatic) cleavage lines being perfectly parallel. Some of the pieces become decidedly fibrous towards the ends and the various individual fibers depart somewhat from true parallelism. In between these fibers, fine-grained aggregates of muscovite can often be seen.

*Published by permission of the Director of the U. S. Geol. Survey.

On a number of pieces a (secondary?) growth of fibers was seen which are probably in all cases dumortierite, as with high powers a faint pleochroism can be detected. They were at first thought to be sillimanite, but they agree in all their properties as far as can be determined with dumortierite. These fibers can be classed in two parts.

In the first part belong those which seem to have formed, as a secondary growth, on the main masses of dumortierite. The fibers branch out considerably and often form a radiating fringe around an entire section of the mineral. They penetrate the quartz grains and interstitial muscovite is absent. The line where they join on to the main mass of the mineral is usually

1

fairly well defined. In general, the fibers are normal to the edge of the main mass, but locally they vary considerably at times, especially where they form fan-like groups.

The second class is clearly a stage in the alteration of the dumortierite to muscovite. The solid mass of dumortierite becomes fibrous and, at the edge breaks up into small fibers which gradually become loose from the parent mass. The space where they formerly joined is now occupied by a granular mass of muscovite which also fills the spaces between the fibers. Gradually this process goes on till finally we have a large mass of granular muscovite, in which are imbedded a few fibrous prisms of the original mineral. Fig. 1 shows diagrammatically a stage in the process.

Basal sections present an entirely different appearance. The macropinacoidal cleavage, so well developed on the New York mineral, does not show on the sections of the California mineral.

The imperfect prismatic cleavage is present and divides the section up into a multitude of irregular bodies. Occasionally a short crack is observed which is parallel to the brachypinacoid, and it may be that the mineral possesses an imperfect interrupted brachypinacoidal cleavage.

The prismatic cleavage was found to be parallel to the prism (210). A large number of measurements gave as the angle (010): cleavage cracks 62°–67°, averaging 64°–65°. The angle (010): (120) is 65° 23′. The cleavage cracks are irregular and it was difficult to obtain any accurate measurements, but the ones made are sufficient to determine the cleavage. They were measured against the trace of the optic axial plane (= (010)).

Polysynthetic twinning lamellæ were observed a number of times and in one particular section (the same on which the prismatic cleavage was measured) were determinable to a certain extent. The alternate lamellæ extinguished together, the difference in angle of extinction of two adjacent lamellæ being 31°. The line joining these lamellæ is parallel to the cleavage or to the prism (210).

The pleochroism of the mineral is beautiful, especially if the section be not too thin. $c = a$ is colorless, $b = b$ is colorless to very faint pink, $a = c$ is deep red purple. None of the sections entirely possess the ordinary blue pleochroism. In some slides, however, there are certain small areas of varied and irregular shape which do show the ordinary pleochroism. These small blue areas in the rich red-purple background make a most beautiful combination. On some sections a large area will have a faint bluish purple color, as if intermediate between the deep blue and the red-purple.

The axial angle on the California dumortierite is small. The following measurements were made with the microscope and micrometer ocular and represent only approximate values.

$$2E_{Li} = 33°$$
$$2E_{Na} = 37°$$
$$2E_{Cu} = 42°$$

The dispersion is $\rho < v$.

The dumortierite from Skamania Co., Washington, was first described by Ford.* Mr. Brereton, of Woodstock, Oregon, kindly sent the writer some specimens on which the following description is based.

The rock is a light-colored fine-grained one, composed of about equal parts of andalusite, quartz and muscovite (determined in thin section).

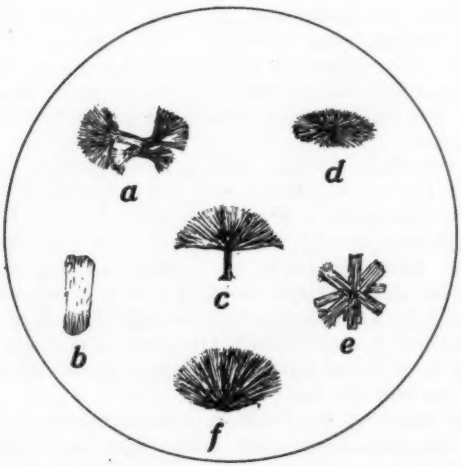
The dumortierite occurs in small spherulites scattered throughout the rock and occasionally bunched together to form a large patch of blue. On an average they reach a diameter of from $\frac{1}{2}$ to 1^{mm}. Their shape, while in general circular, is often

* This Journal (4), xiv, 426.

elliptical and may become very irregular in places. The spherulites consist of fibers radially arranged and show all the optical phenomena of "spherulites." The dumortierite has parallel extinction and its birefringence is somewhat higher than that of the quartz and also slightly more than that of the andalusite, though the difference between that of the latter two minerals is very small.

The intensity of the pleochroism of the dumortierite varies so that in some spherules there are concentric bands of fibers varying greatly in the intensity of their color. Some are almost colorless, and it was at first thought they might be par-

2



allel growths of andalusite with the dumortierite, but such a conclusion could not be verified.

The fibers are not always perfectly radial. They are at times gathered into "brushes" and a number of these put together may form a spherulite. The fibers are thus more thickly crowded in places than elsewhere, and this frequently results in intensifying the pleochroism, so that in some spherulites there are numerous blotches of blue much deeper colored than the rest. Muscovite is frequently abundant in a spherulite, being formed between the fibers, and is probably an alteration product of the dumortierite. Frequently a mass of dumortierite will be almost completely changed to mica, leaving but small fragments of the original mineral behind.

The fibers of dumortierite, while usually arranged radially, sometimes assume different shapes, and some of the masses of dumortierite seen under the microscope are reproduced in fig. 2.

Fig. 2 shows variations from typical spherulitic form that the fibers of dumortierite assume. *a* is four prisms irregularly joined at the center, the ends spreading out into "brushes" of fine fibers. This form is fairly abundant. *b* forms a prismatic portion becoming fibrous at both ends, and while common in the New York, Arizona, and California occurrences is a rare type for Washington dumortierite. *c* forms a sort of fan and is composed of several "brushes" joined together. It is a common type. *d* is an elliptical spherulite. *e* is a mass of prisms such as *b* but not spreading out as *a* does. It is of rarer occurrence. *f* is a bunch of radial fibers with no prismatic stem as in *c*. It is fairly common.

Crystallographic.

The mineral is orthorhombic and from the various measurements the following axial elements have been calculated:

$$a = \cdot 8897 \qquad c = \cdot 6871$$

The crystals were measured with the two-circle goniometer, and the values for p_0 and q_0, from which the above ratios are obtained, are:

$$p_0 = \cdot 7723 \qquad q_0 = \cdot 6871$$

The forms observed are as follows:

$b = 0\,\infty = 010$	$g = \frac{3}{2}\,\infty = 320$
$a = \infty\,0 = 100$	$n = 2\,\infty = 210$
$l = \infty\,2 = 120$	$d = \frac{1}{2}\,0 = 102$
$m = \infty = 110$	$v = \frac{2}{3}\,0 = 203$

Besides these forms, reflections were obtained from several other minute faces, but they were so minute and the reflections so poor that their validity is very questionable and they are omitted from the foregoing list. The average of the measured angles compared with the calculated values are shown in the following table:

Letter.	Symbol.	Measured.		Calculated.	
		ϕ	ρ	ϕ	ρ
b	$0\,\infty = 010$	0° 00′	90° 90′	0° 00′	90° 00′
a	$\infty\,0 = 100$	91 23	"	90 00	"
l	$\infty\,2 = 120$	29 19	"	29 20	"
m	$\infty = 110$	49 01	"	48 20	"
g	$\frac{3}{2}\,\infty = 320$	59 49	"	59 19	"
n	$2\,\infty = 210$	65 23	"	66 01	"
d	$\frac{1}{2}\,0 = 102$	91 21	21 46	90 00	21 07
v	$\frac{2}{3}\,0 = 203$	87 39	26 58	"	27 14

The brachypinacoid is present on four crystals, usually as broad faces. Some give relatively good reflections.

The macropinacoid occurs on all the crystals except the one from Arizona. The reflections were poor but serve to identify the form. The ϕ angles measured are as follows:

90° 02′	(Cal.)	Calc. 90° 00′
93 46	"	
90 00	"	
92 57	(N. Y.)	
91 15	"	
90 16	"	

The brachyprism $l = \infty 2 = 120$ occurs on four crystals, giving fair reflections.

Meas. (ϕ) 30° 00′	(Cal.)	Calc. (ϕ) 29° 20′
28 00	"	
29 22	"	
29 34	(N. Y.)	
29 39	"	

The unit prism is poorly developed on the California crystals, being present but once as a narrow face giving a poor reflection. On the Arizona crystal it occurs twice as broad faces.

Meas. (ϕ) 48° 52′	(Cal.)	Calc. (ϕ) 48° 20′
49 16	(Ariz.)	

The macroprism $g = \frac{3}{2}\infty = 320$ is present several times on all the crystals except the one from Arizona. The measured angles vary somewhat.

Meas. (ϕ) 58° 55′	(Cal.)	Calc. (ϕ) 59° 19′
59 42	"	
60 36	"	
59 38	"	
59 23	"	
60 14	"	
59 04	(N. Y.)	
60 07	"	
59 25	"	
60 23	"	
60 31	"	

The macroprism $n = 2\infty = 210$ is present four times. The reflections were fair.

Meas. (ϕ) 65° 26′	(Cal.)	Calc. (ϕ) 66° 01′
65 35	"	
65 19	"	
65 12	"	

The macrodome $d = \frac{1}{2}0 = 102$ is present once on the Arizona crystal. The reflections were not very good. The dome $v = \frac{2}{3}0 = 203$ is present on one of the California crystals. The

face is exceedingly minute and is not shown in the drawing, fig. 3, A, and the reflection was poor.

On crystal No. 4 (N. Y.) were observed two very small faces, giving poor reflections.

	ϕ	ρ
(1)	83° 46′	17° 54′
	83 16	17 44
(2)	80 19	16 50
	84 17	17 28

These agree approximately with the symbol $\{8.\ 1.\ 20\}$ or considering the form vicinal to a dome, to $\{205\}$.

The following table gives the calculation of the forms of dumortierite based on the elements given in this paper. The table corresponds to those given in Goldschmidt's Winkeltabellen.

$a = 0.8897$	$lga = 9.94924$	$lga_0 = 0.11202$	$lgb_0 = 9.88779$	$a_0 = 1.2943$	$p_0 = 0.7723$
$c = 0.6871$	$lgc = 9.83702$	$lgb_0 = 0.16298$	$lgq_0 = 9.83702$	$b_0 = 1.4554$	$q_0 = 0.6871$

No.	Letter	Sym. Gdt	Sym. Miller	ϕ	ρ	ξ_0	η_0	ξ	n	χ (Prism) $x : y$	y	$d = tg\,\rho$
1	b	$0\,\infty$	010	0° 00′	90° 00′	0° 00′	90° 00′	0° 00′	90° 00′	0	∞	∞
2	a	$\infty\,0$	100	90 00	"	90 00	0 00	90 00	0 00	∞	0	"
3	l	$\infty\,2$	120	29 07	"	"	90 00	29 07	60 53	0.5570	∞	"
4	m	∞	110	49 01	"	"	"	49 01	40 59	1.1510	"	"
5	g	$\frac{1}{2}\infty$	320	59 47	"	"	"	59 47	30 13	1.7170	"	"
6	n	2∞	210	65 23	"	"	"	65 23	24 37	2.1825	"	"
7	d	$\frac{1}{2}0$	102	90 00	21 07	21 07	0 00	21 07	0 00	0.3862	0	0.3862
8	v	$\frac{2}{3}0$	203	"	27 14	27 14	"	27 14	"	0.5147	0	0.5147

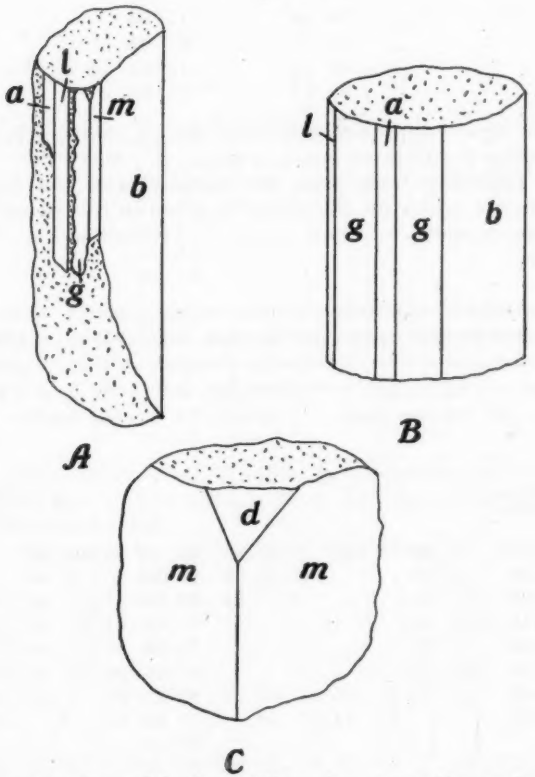
The combination seen on the six crystals measured are:

No. 1	Cal.	b,	a,	l,	m,	g,	n,	—,	v,
" 2	"	b,	a,	l,	—,	g,	n,	—,	—,
" 3	Ariz.	—,	—,	—,	m,	—,	—,	d,	—,
" 4	N. Y.	b,	a,	—,	—,	g,	—,	—,	—,
" 5	"	b,	a,	l,	—,	g,	—,	—,	—,
" 6	"	—,	a,	l,	—,	g,	—,	—,	—,

Fig. 3 shows three of the crystals.

A is from California, size $1^{mm} \times \frac{1}{4}^{mm}$.
B " New York, about $1^{mm} \times \frac{1}{2}^{mm}$.
C " Arizona, about $1^{mm} \times 1^{mm}$.

3



The minerals andalusite, sillimanite, staurolite and dumortierite possess certain properties that are very similar. They are all orthorhombic, their axial ratios are similar, their principal constituents are silica and alumina, and in many ways these minerals can well be grouped together. A comparison of their axial ratios is given below:

	a	*c*
Adalusite	·9861	·7025
Sillimanite	·970	?
Staurolite	·9795	·6942
Dumortierite	·8897	·6871

For staurolite the values are taken from Goldschmidt's Winkeltabellen with the *a* and *c* axes interchanged.

There was some question in the writer's mind as to whether the orientation chosen was the best or whether the present prism {210} had not better be made the unit prism. The cleavage is parallel to this prism and the twinning also bears some relation to this form. Moreover, the ratio above given for staurolite, though adopted by Goldschmidt, is not, in the writer's opinion, the best one for that mineral. The one given by Dana, who makes the *a* axis just half as long, would be the better one. The common form of staurolite is prismatic with a prismatic angle of 50° 40′ (Dana).

For andalusite, on the other hand, the prismatic angle is 89° 12′ and the *a* axis should be ·9861 as given. Should dumortierite be classed crystallographically with staurolite or with andalusite? Unfortunately, the evidence is almost too meager to decide this question. On the California crystals the unit prism is poorly developed, and entirely absent from the New York crystals, the strongest form next to the brachypinacoid being the prism {320}. The prismatic cleavage is parallel to {210}, and making the cleavage form the unit prism the *a* axis should be given half its present value. On the other hand, the Arizona crystal is of the typical andalusite habit and making the prism the unit one, we obtain the axes as here given. Giving staurolite the (approximate) axes as andalusite and dumortierite, the prismatic cleavage is parallel to the same form as in dumortierite, namely {210}.

Chemical.

In 1881, after the first announcement of the discovery of the mineral had been made by Gonnard, Damour gave the following analysis of the mineral:

SiO_2	29·85
Al_2O_3	66·02
Fe_2O_3	1·01
MgO	·45
Ign.	2·25
	99·58

Sp. gr. 3·36

From this analysis the formula $4Al_2O_3.3SiO_2$ was calculated. Damour did not suspect the presence of boric acid in the mineral and what was weighed as alumina probably contained several per cent B_2O_3. In 1887 Riggs gave an analysis of the New York mineral in which he found 4 per cent B_2O_3. Two years later Whitfield gave several analyses of American dumortierite, all showing the presence of B_2O_3. In 1899 Linck gave some observations on the mineral, including an analysis by

W. Schimpff showing a strong test for boric acid. In 1902 Ford gave us three analyses of American dumortierite and also mentioned two new localities. During the winter of 1903–4 the writer made an analysis of the California dumortierite collected by himself during the previous summer. An analysis was also made at the same time of the Washington dumortierite kindly furnished by Mr. Brereton.

Believing that one good analysis is better than several poorer ones for the exact determination of the formula of the mineral, there will be presented an analysis of the California dumortierite made by the writer. From this a formula has been calculated for the mineral, and it will be shown how the other analyses agree with this proposed formula. Before giving the results a few preliminary words will not be out of place.

An analysis of dumortierite is a difficult operation. The small amount of silica makes it difficult to get a good fusion. On preliminary trials on an analysis of the California dumortierite, it was found that what was weighed as silica, in the regular course of the analysis, contained more or less of the undecomposed mineral. Results of about 30 to 32 per cent were obtained. This is, of course, on the uncorrected silica. It was found that a second fusion of the supposed silica was not only very beneficial but also necessary. What was then weighed as silica contained but little residue. The handling of so large an amount of alumina is very cumbersome and an accurate determination of the alumina (plus iron and other oxides here precipitated) is difficult. The boric acid determination is a tedious and difficult one. The accurate determination of the water, which is only given off at a high temperature, is also not easy. One can thus see that an analysis of such a mineral is a difficult operation and that a greater allowance must be made than for most silicate mineral analyses.

The specimen analyzed was selected in the field, an exceedingly pure piece weighing about ten grams being selected. The specific gravity of this piece was taken by suspension in water, giving 3·306. This was broken into small pieces and carefully examined for muscovite, quartz, or other minerals. Sections of the mineral showed that the dumortierite was free from any inclusions. No grains of any titanium mineral abundant in the quartz could be detected. When the mineral was powdered it was treated with heavy solution of sp. gr. 3·10, and a minute amount of mineral (muscovite?) stayed on top and was removed. The separation was repeated several times, the powder dried at 100° and carefully examined under the microscope for impurities. None were found. The mineral was unquestionably pure.

The general analytical methods used were those pursued in the Survey laboratory for silicate analysis with a few modifications. The mineral was fused with sodium carbonate, the

silica separated and refused with sodium carbonate. The silica was filtered off and weighed and treated with HF, which left some residue. The alumina (plus iron and titanium) was precipitated three times to be sure of removing all of the sodium salts. It was ignited and weighed with the silica residue, fused with sodium bisulphate, some silica recovered, the iron reduced and determined by titration and the titanium determined colorimetrically. The presence of titanium was suspected from the color of the pleochroism of the mineral. The boric acid was determined by the Gooch method, using all of the known precautions. The mineral was twice fused with sodium carbonate and the boric acid was finally weighed as lime borate. The water was collected in a calcium chloride tube, the mineral being heated in a Gooch tubulated crucible in the usual manner. A blank determination was run before and after each water determination and a small correction applied. All possible precautions were taken throughout the analysis, which was made in duplicate. The results are:

	1	2	Average.
SiO_2	28·58	28·78	28·68
Al_2O_3	63·31	63·30	63·31
Ti_2O_3	1·49	1·40	1·45
Fe_2O_3	·21	·25	·23
H_2O	1·53	1·51	1·52
B_2O_3	5·21	5·53	5·37
	100·33	100·77	100·56

The titanium is regarded as present as Ti_2O_3, replacing the alumina.

Combining the alumina, titanium and iron, the following ratios are obtained:

SiO_2	5·94	or	6
Al_2O_3	8·00		8
B_2O_3	1·06		1
H_2O	·96		1

The formula for dumortierite then is

$$8Al_2O_3 . 1B_2O_3 . 1H_2O . 6SiO_2.$$

It has not been proven that either boric acid and alumina or boric acid and hydroxyl may mutually replace each other in minerals as fluorine and hydroxyl are known to do. There is then no reason that the writer can see why the alumina, boric acid and water in dumortierite should not be present in fixed quantities; that the variations shown in analyses are not due to "isomorphous replacements" but to inaccuracy of analyses or impure material.

Having established the above formula from the analysis, let us see how close the other analyses conform to the formula.

The best series of analyses is that by Ford from three American localities. His first analyses of the Arizona mineral are:

	1	2	3	Average.
SiO_2	30·00	29·66	29·91	29·86
Al_2O_3	63·20	63·74	63·76	63·56
Fe_2O_3	·23	·23		·23
B_2O_3	5·47	5·06		5·26
H_2O	1·45	1·38		1·41
				100·32

The ratios calculated from the average analysis gives:

SiO_2	6·29	or	6 × 1·05
Al_2O_3	7·94		8 × ·99
B_2O_3	·96		1 × ·96
H_2O	1·00		1 × 1·00

The agreement with the proposed formula is perfect.

His second analysis, that of the California mineral, shows slight variations from the results obtained by the writer. The presence of titanium was not determined. His analysis is:

		Ratios.		
SiO_2	30·58	6·17	or	6 × 1·03
Al_2O_3	61·83	7·40		8 × ·93
Fe_2O_3	·36			
B_2O_3	5·93	1·04		1 × 1·04
H_2O	2·14	1·45		1 × 1·45
	100·84			

The ratios agree well with the new formula except for the water content. Remembering, however, that the amount of water present is very small and that a difference of ·10 per cent would make a large difference in the ratios, that Ford determined his water by igniting the mineral with lime, thus not weighing the water directly, and that the writer obtained only 1·52 per cent on the same mineral from the same locality, it seems much more preferable to regard the determination of the water in Ford's analysis as too high rather than to attempt an explanation of it by the assumption of "isomorphous replacement, etc."

Of the third analysis by Ford, of the New York mineral, he says: "It is fully realized that the results are not to be looked upon as being as exact as those of the other analyses." His analysis is:

		Ratios.		
SiO_2	31·24	6·23	or	6 × 1·04
Al_2O_3	61·26	7·23		8 × ·90
Fe_2O_3	·10			
B_2O_3	6·14	1·06		1 × 1·06
H_2O	2·09	1·40		1 × 1·40
	100·83			

Again assuming that his water content is somewhat high, the ratios agree well with the new formula.

This concludes the list of analyses of dumortierite which were made on pure material and with due knowledge of what was to be determined. A number of other analyses will now be given which serve in a general way for the determination of the composition of the mineral, but can not be relied on for exact results.

One, which has heretofore not been published, was made by the writer on the Washington dumortierite. About 200 grams of the rock was powdered and by repeated separation with heavy solutions about 4 grams of dumortierite were obtained. The sample was by no means pure. It was found impossible to remove all the andalusite, an unknown but small amount remaining. It was found during the course of the analysis that the sample also contained some titanite (leucoxene) and a very small amount of pyrite. The analysis was made with all the care possible and the following results were obtained:

		Ratios after deducing titanite.	
SO_3	28·51	5·97	or 6 × ·99
Al_2O_3	59·75		
Fe_2O_3	2·48	7·80	8 × ·97
TiO_2	·95		
H_2O	2·12	1·53	1 × 1·53
B_2O_3	5·54	1·03	1 × 1·03
CaO	·68		
	100·03		

Excepting for the high-water content, the analysis agrees very well with the formula. No allowance was made for the small amount of andalusite present, which would slightly alter the ratios.

There now remain the analyses of Whitfield and Riggs, of which but one is suitable for any calculation. The analyses are as follows, No. 1 being of the New York mineral, by Riggs, No. 2 of the New York, and Nos. 3 and 4 of the Arizona mineral, by Whitfield:

	1	2	3	4
SiO_2	34·82	31·44	31·52	27·99
Al_2O_3	55·30	68·91	63·66	64·49
MgO	·57	----	·52	tr.
K_2O	1·04	----	·11	----
Na_2O	1·76	----	·37	----
P_2O_5	----	----	----	·20
B_2O_3	4·07	tr.	2·62	4·95
Ign	2·96	----	1·34	1·72
	100·52	100·35	100·14	99·35

The ratios of the last analysis are:

SiO_2	5·94	or	6 × ·99
Al_2O_3	8·09		8 × 1·01
B_2O_3	·80		1 × ·80
H_2O	1·22		1 × 1·22

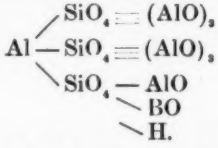
Approximately they agree with the formula.

The only question of which there seems to be any doubt is whether the water should be 1 or 1½ molecule. As, however, the best analyses show but 1 molecule and their evidence is considered as of much more value than a large number of inferior analyses, there is no question in the writer's mind but that the formula for dumortierite is

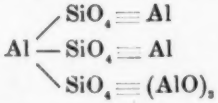
$$8Al_2O_3.1B_2O_3.1H_2O.6SiO_2.$$

This may be written $(SiO_4)_3Al(AlO)_7(BO)H$, which is the same as the formula given by Groth except that for (BO) he puts (AlO). His formula is $(SiO_4)_3Al(AlO)_8H$.

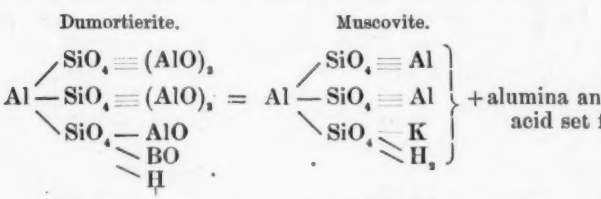
This may be written in the following form:



This formula is similar to that of andalusite, which is written



Dumortierite alters to muscovite. The change can be very well shown by these formulæ and seems to be entirely in accordance with the group of minerals to which it is related.



The writer's thanks are due to Mr. John A. Thoman of San Diego, the owner of the California dumortierite property, and to Mr. K. C. Naylor of San Diego, for many courtesies and favors.

ART. XVII.—*Crystallography of Lepidolite;* by WALDEMAR T. SCHALLER.

A GROUP of lepidolite crystals was collected by the writer in the summer of 1904, at a gem mine about four miles east of Ramona, on the stage road from Ramona to Julian, San Diego County, California. The mine was opened and worked for its gems, such as topaz, tourmaline, garnet, etc. With these are associated quartz, orthoclase in good crystals at times several feet long, and muscovite, and, rarely, lepidolite. The minerals in question all occur in the loose dirt, filling "pockets" in a pegmatite dike.

The specimen of lepidolite under consideration consists of a group of intergrown crystals which often reach a large size. The group itself is about 5^{cm} thick and the individual crystals measure about 1^{cm} across the base, though ones with a diameter of 2^{cm} are not rare. The crystals are also proportionally thick, the average being from 2 to 4^{mm}, though a few are somewhat thicker. They are transparent and of a very pale pink color, and, in the direction normal to the vertical axis and parallel to the base, of a slightly deeper tint. They fuse easily to a white enamel, coloring the flame an intense crimson. The side faces are usually plain, not rounded nor striated, and of a brilliant polish, giving excellent signals. It is, however, extremely difficult to secure a complete crystal from the group, owing to the perfect basal cleavage which will cause a crystal to split into a number of layers. This will also at times cause part of a crystal to become slightly displaced. In consequence of this difficulty, most of the crystals measured are only parts of the original crystals, and two such pieces measured as separate crystals may, in reality, be parts of one and the same crystal.

As may be expected, the crystals of lepidolite are similar to those of muscovite. The interfacial angles are nearly the same and the crystals are naturally referred to the same axes as muscovite. There are three marked differences between these crystals and those of muscovite: (1) the rarity of twins—only one being found in twenty-one crystals; (2) the absence of the characteristic face of muscovite, $M = \{221\}$; and (3) the presence of the *a* face $\{100\}$, occurring on ten out of twenty-one crystals. The crystals are not so striated as the green North Carolina muscovites for instance, and in many cases the faces yielded perfect signals.

The common forms are $c = \{001\}$, $b = \{010\}$, $a = \{100\}$, $e = \{023\}$, $o = \{112\}$, $u = \{\bar{1}11\}$, and $x = \{\bar{1}31\}$. Besides these, the following have been determined; $N = \{261\}$, $z = \{\bar{1}32\}$, 1

= {130}, and possibly several others, as {$\bar{2}23$}, {$\bar{2}21$}, {$\bar{1}12$}. Also a number of forms occurring for the most part as broad faces, giving good reflections but having anomalous indices and which need further study. The most frequent combination is *cboux*, after which comes *cbouxea*. Whenever the angle (001) : (010) could be accurately measured, it was found to be exactly 90° 00′ in every case, and the distribution of the faces also indicate monoclinic symmetry.

It was noticed that the angle between the same forms varied slightly on different crystals. The faces were smooth and highly polished and the angles could easily be measured with an error nor greater than 1′. It is suggested that this variation is real and is due to the fact that lepidolite is an isomorphous mixture of two end products, and as the ratio of these two products varies, the crystallographic and physical properties of the mineral also vary. Further study on the possible correlation of the various properties of the mineral is under way.

This lepidolite belongs to the "second class" of Tschermak or the "brachydiagonal class" of Scharizer, i. e., the axial plane is parallel to the clinopinacoid, and not normal to it. The trace of the axial plane was always parallel to one arm of the percussion figure. The above is only a brief preliminary statement; the detailed crystallography of the mineral will soon be published in a paper on the mineralogy of this entire field of lithium minerals in southern California. The writer's thanks are due Mr. Pan McIntosh, Jr., of Ramona, the owner of the mine.

Chemical Laboratory, U. S. Geological Survey.

ART. XVIII.—*Machine-Made Line Drawings for the Illustration of Scientific Papers;* by R. A. DALY.

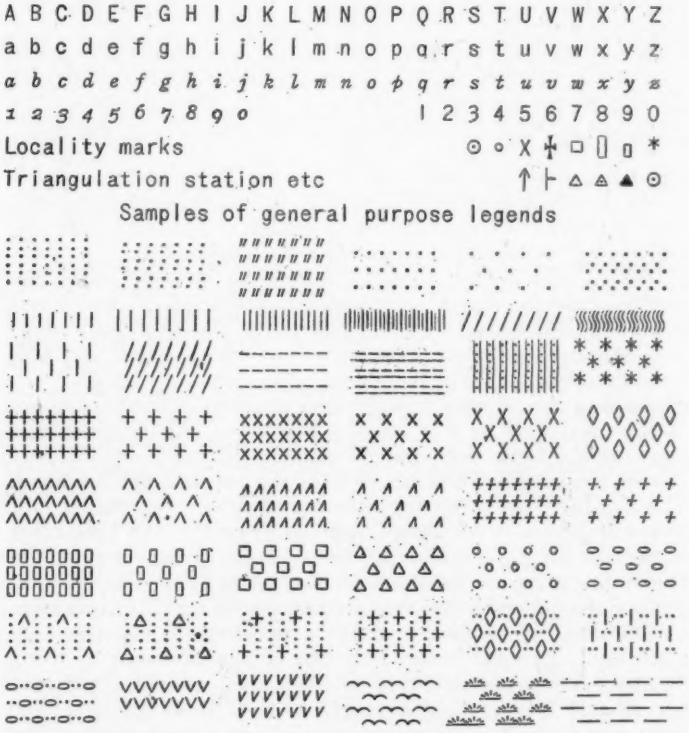
IT is safe to say that the majority of persons, who from time to time publish scientific papers, are seriously hampered in the preparation of text illustrations by the difficulty and expense entailed in the tedious drawing of map, section or diagram. Comparatively few authors can command the services of skilled draughtsmen or have themselves the requisite training to produce satisfactory line drawings. Yet the desirability of greatly increasing the proportion of such illustrations in the thousands of scientific articles published each year is manifest. That clearness, precision and conciseness in the exposition of a theme are generally enhanced by the use of abundant, appropriate diagrams is as evident as that the blackboard is the constant friend of the teacher of any branch of natural history or philosophy; the printed page needs its blackboard.

Ideally, the author should himself be able to make the original drawing quickly, neatly and artistically. The usual execution of drawing with the pen is, to the average author, discouragingly slow and expensive, not always neat, and still less often artistic. The following note relates to some experiments made to increase rapidity and neatness in the production of line drawings by the use of a machine. At the outset the experiments were, for obvious reasons, planned without any idea of rivalling the artistic work of the pen in a skilled hand. The aim has been to secure economy of time in execution and clear-cut precision of legend for the drawing. In both these respects enough success has been attained to warrant the recommendation of the machine method to geologists, geographers and others who desire to prepare useful text illustrations at a minimum cost of labor. Some experimental drawings were made and published in the Bulletins of the Museum of Comparative Zoology at Harvard College, vol. xxxviii, 1902, pls. 11, 12 and 13; in this Journal, August 1903, pp. 118 and 120; and in the American Geologist, August 1903, p. 66. The machine there used was an ordinary Underwood typewriter fitted with a black record silk ribbon.

Recently the Hammond Typewriter Company of New York has constructed, for the Geological Survey Department of Canada, from the writer's specifications, a typewriter provided with a carbon ribbon and with ninety special characters designed for the preparation of line drawings to accompany geological and geographical papers. The same machine can be similarly used for statistical, engineering and other diagrams of a more or

less mechanical and simple composition. Of course this method should not wholly replace the use of the pen, even, for example, in the differentiation of areas in a geological map or section. The ultra mechanical look of the typewritten legend can often be pleasingly relieved by the easily and quickly applied cross-hatchings, etc., made with an ordinary drawing pen. In com-

1

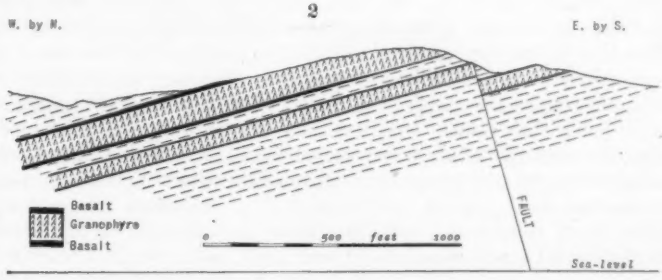

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z
1 2 3 4 5 6 7 8 9 0
1 2 3 4 5 6 7 8 9 0
Locality marks
Triangulation station etc
Samples of general purpose legends

plex diagrams free-hand work may generally be expected to supplement the work of the machine. The subject of each diagram should thus be studied with the end of securing suitable contrasts of legend along with the maximum economy of pen work; yet some pen work is almost always necessary.

The typewriter has its most general application in lettering, that most difficult element in line drawings. The machine used by the writer has the advantage of making it possible to employ a great range of type styles. With the carbon ribbon the writer has found that any one of the one hundred and

twenty-five shuttles made for such a machine (each shuttle bearing ninety characters and including the lettering for one of twenty-six different languages), will give an impression suitable for photographic reproduction. Each shuttle can be placed in the machine ready for work in a few seconds. The usual silk ribbon gives a "woolly" line, and is far less satisfactory than the carbon ribbon. A highly calendered and high-grade linen paper of a medium to heavy weight or a thin Bristol board may be recommended. Often more than one impression of the key is necessary to obtain the required depth of tint for photography; such repeated impressions can be made at great speed by employing a back spacing key. Care must be taken not to smudge the carbon of the completed printing.

2



The accompanying cuts serve to show something of the method as applied to geological diagrams. The diagram (fig. 1) of alphabets and legends has been reduced to four-fifths of its original diameter. The legends are intended to represent a few examples of those possible with the machine. They can be indefinitely increased in number and varied in design by the engraving of new characters on the shuttle, and by using various permutations and combinations of the existing characters. The section (fig. 2) is reduced to about one-half of its original diameter. It was copied from Harker's section of a composite triple sill published in "The Tertiary Igneous Rocks of Skye" (Memoir of the Geological Survey of the United Kingdom, 1904, p. 204). The result represents the saving of from seventy-five to ninety per cent of the time required by a draughtsman to duplicate the drawing.

It is to be understood, of course, in the preparation of a diagram that an outline drawing is first prepared, and that the spaces thus formed are filled with the symbols shown in the legends, by means of the machine.

Ottawa, Canada.

Art. XIX. — *Iodobromite in Arizona;* by William P. Blake.

The rare compound of silver, iodine, bromine and chlorine, iodobromite, occurs in thin seams and crusts in a vein of quartz and calcite near Globe, Pinal County, Arizona. The crystallization is obscure. It is soft like talc; luster vitreous; color light lemon-yellow to sulphur- and canary-yellow. Not being able to secure enough for a satisfactory quantitative analysis, the results of the determinative tests are added. The reactions before the blowpipe are remarkably beautiful and interesting. Heated in a closed tube with bisulphate of potash, the mineral quickly changes color to a dark salmon, or orange-red, heavy brownish-red fumes of bromine are given off and bromine condenses in the higher portion of the tube; violet vapor of iodine then appears and crystals of iodine form below the condensed bromine. The fused assay, floating in the flux, is brilliant cherry red, at first very dark red, but on cooling gradually loses this color, passing through various shades of red until the normal yellow color is restored. The fused mass then being removed from the tube and reheated until the bromine and iodine are expelled, and treated with carbonate of soda on charcoal, a button of metallic silver is obtained. The fused carbonate of soda dissolved from the coal gives the reaction for chlorine with silver nitrate. In the final reduction of the assay to the metal a slight yellow areola like that from lead was observed and referred to probable slight impurity.

Arizona School of Mines, Tucson, Arizona.

ART. XX.—*Autophytography: A Process of Plant Fossilization;* by CHARLES HENRY WHITE.

THE evidence for the existence of plant life on the earth in past geological ages is both direct and indirect. We may include in the class of direct evidence all the records of vegetable life in which the form or structure of the plant is in any degree preserved, and in the class of indirect evidence, such as offer no clew to plant form, but merely indicate in a secondary way, the existence of vegetable life. In this latter class are coal and certain deposits of calcareous and siliceous sinters and bog-iron-ore. The plant records to which attention is especially directed in this paper may be placed in the category of direct evidence, since the trace or outline of the plant is distinctly preserved; but the process by which the outline is recorded in the rocks is wholly different from those processes to which the formation of plant records is usually attributed.

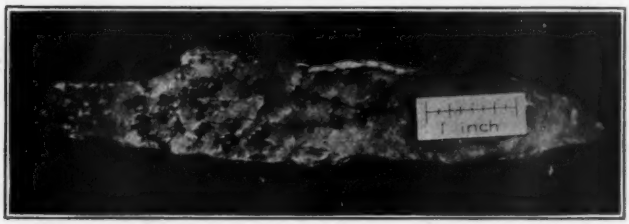
The ways usually described by which the plant form is recorded in the rocks may be included in the following three classes. The first class includes those in which the original substance, or tissue, of the plant is, in part at least, preserved. Such remains are often found within, or in close association with, deposits of shale, peat, coal, diatomaceous earth, and the like. The second class of records by which the form is preserved is that in which the plant tissues have been removed by decay or otherwise, leaving only the impress or mould as the record in the rocks. The third class is that in which the mould has been filled by a cast, either after the complete removal of the plant, or by a gradual so-called molecular replacement.

By the process of plant fossilization here described, the plant undergoing decomposition reproduces itself in outline on the rock surface upon which it rests, or upon the matrix within which it is enclosed, either by the precipitation of colored mineral matter, or by the alteration or removal of the coloring matter already in the rock. In the first of these processes the rock surface receives a deposit of colored mineral matter, a positive picture,—to borrow the language of the photographer,—is made (see figures 1 and 2); and in the second, the uniform coloring matter already in the rock is abstracted where the plant, during growth or decay, has been in contact with it, giving a plant picture in lighter color, a negative (figures 3 and 4). For such plant pictures, or plant writings, in which the traces or outlines of plants are distinguishable by their color, and in which the variation of color from the matrix is due to chemical change brought about by the plant reproduced,

the name autophytograph (*αὐτός* = self, *φυτόν* = plant, *γραφω* = write) is proposed.

Figures 1 and 2 represent specimens of the positive autophytograph that were collected by Dr. John W. White in December, 1897, from a bar of gravel on Cub Creek in the town of

1



2

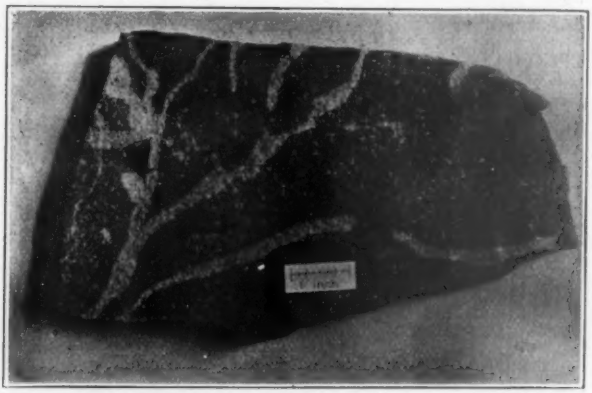
Wilkesboro, North Carolina, and were presented to the writer in January, 1898. These specimens* are water-worn pebbles of white quartzite that have been slightly stained brownish yellow by hydrated iron oxide, and that have, in recent time,

* All the specimens reproduced here are in the Harvard University Museum. Figures 1 and 2 are from two specimens No. 2559, figures 3 and 4 are Nos. 2667 and 2343, of the Geological Laboratory collection; and figure 5 is from No. 37 of the Students Palaeontological collection.

received a black deposit on their polished and stained surfaces, reproducing so perfectly the stem and leaves of a small herb that the species is readily identified. These autophytographs were determined by Mr. M. L. Fernald at the Gray Herbarium, Harvard University, through the kind intervention of Mr. Walter Deane, of Cambridge, Massachusetts, as having been produced by *Micranthemum orbiculatum* Michx., a small creeper that flourishes in low, muddy ground, from Florida to North Carolina.

The composition of the pigment of these autophytographs is difficult to determine, owing to the small quantity of material available. It is, however, a black adherent deposit, insoluble

3



in water, but slowly attacked by the mineral acids, yielding solutions which show the presence of iron. No change of color is produced by the flame of the blow-pipe, but the pigment becomes strongly magnetic on heating. There is no doubt, therefore, that the colored deposit contains iron, and it is most probably an oxide. Two possible conditions under which it is believed such a deposit could form are suggested. First, the plants of this genus may yield on decomposition a precipitant of iron, peculiar to the genus, which extracts iron from the surrounding solutions and deposits it in a manner analogous to one of the artificial ink-making processes, and on exposure to the air the precipitate is changed to an oxide. The other suggestion is, that the conditions of decay are such that ammonia is liberated in the presence of iron in solution, precipitating the iron on the rock upon which the plant rests

during decay. For the precipitate to remain permanent, ammonia must be produced gradually and in sufficient quantity to neutralize the acid in the iron-bearing solution until the acid ceases to flow to the point of deposition. That vegetable matter undergoing decay will under certain and usual conditions produce acids which take iron in solution, and will under other conditions yield ammonia, is well known and need not be discussed here; but the nicety of adjustment of these conditions called for above would necessarily be rare, and,—if this be the correct theory,—would account for the scarcity of autophytographs of this description.

4

In figures 3, 4 and 5 are reproduced autophytographs of the negative type. The specimens represented by figures 3 and 4 are autophytographs of recent formation that were collected by Professor J. B. Woodworth of Harvard University, and it is through his kindness that they are here reproduced. The specimen represented by figure 3 is a block of sandstone, taken from the Saratogan, or upper Cambrian, formation near Biddle's Crossing, about a mile and three-quarters north of Sciota, Moore's quadrangle, Clinton County, New York, on which rootlets have in recent time brought about solution of the iron-pigment which stained the sandstone a yellow-brown, giving an autophytograph of lighter color on a dark background. Figure 4 represents a specimen taken from the ploughed surface of a lateral moraine at the west base of Bald Hill near Caroline Depot, Tompkins County, New York. This specimen

differs from the last only in having a darker iron-pigment in the rock, and in the form of the root reproduced, but in neither case is the portion of the plant reproduced sufficiently characteristic to identify the species.

These autophytographs belong in no sense to a past geological age. They were formed on or near the present land surface and show little evidence of having suffered disintegration and erosion. Granting that in transportation and deposition the probabilities are decidedly in favor of the destruction of these plant records, yet there are conditions of deposition and

5

burial, not at all rare in nature, that would very effectively preserve such records to future geological time. While the specimens so far considered belong to the present and have no value as records for the historical geologist or palaeontologist, they well illustrate the process of autophytography and, as just pointed out, lead us to expect fossils of this character in the plant-bearing horizons of past geological time.

At the suggestion of Professor R. T. Jackson, the collection of fossil plants in the Harvard Botanical Museum was inspected, and it was found that fossil plants from many horizons partake of the quality of the autophytograph of both the positive and the negative type. Plant impressions in the slates at Solenhofen, Bavaria, marked out by oxide of iron have been observed

by Seward,* and similar impressions in the Buntersandstein of the Vosges were found by Schimper and Mougeot† to have either received a deposit of hydrated ferric oxide or to have had the red color of the rock removed from about the plant impression, the intensification or the removal of the coloring depending on the locality and the nature of the rock. In the Harvard collection are representatives of both these types from the Vosges and also from the Solenhofen deposits, as well as from many other localities. There are also examples in which the plant has left no impression or mould on the rock, but, at the same time, has been perfectly fossilized by negative autophytography. A fair representative of this class from the Lias of Germany is shown in figure 5. It is a specimen of *Fucoides bollensis*, collected at Boll, Würtemberg.

The various classes of evidence for the existence of plant life may be summarized as follows:

- Evidences of plant life
  - Direct
    - Vegetable substance
      - Original tissue
      - Carbonized
    - Mould or impression
    - Cast
      - External form only
      - Internal structure
    - Autophytograph
      - Positive
      - Negative
  - Indirect .. Graphite, coal, sinter, bog-iron-ore

Harvard University, Cambridge, Mass.

* A. C. Seward, Fossil Plants, vol. i, p. 68.

† Schimper et Mougeot, Monographie des plantes fossiles du grès bigarré de la Chaîne des Vosges, p. 10.

ART. XXI.—*The Oxidation of Sulphites by Iodine in Alkaline Solution;* by R. HARMAN ASHLEY.

[Contributions from the Kent Chemical Laboratory of Yale Univ.—CXXXIV.]

ACCORDING to Bunsen, Dupasquer's method of oxidizing sulphurous acid by iodine in an acid solution, proceeds to completion according to the equation

$$2SO_2+2I_2+4H_2O=4HI+2H_2SO_4$$

only when the concentration of the sulphur dioxide does not exceed 0·5 per cent of the solution. When, on the other hand, the proportion of sulphur dioxide exceeds this value, there is a secondary reaction, which according to Volhard, involves the reduction of the sulphur dioxide by the hydriodic acid produced. This difficulty may be obviated, however, as has been shown by Volhard,* if the solution of the sulphurous acid or a sulphite is run with stirring into a solution of iodine in potassium iodide, acidified with hydrochloric acid, to the bleaching of color, using starch as an indicator,—a procedure which is obviously less convenient than direct titration by a standard solution of iodine.

It has been recently further proposed by E. Rupp† to accomplish the oxidation in an alkaline solution, by treating the solution of sulphur dioxide or a sulphite, with an excess of standard iodine in presence of acid sodium carbonate, 1 gr., during an interval of fifteen minutes, and determining the excess of iodine with sodium thiosulphate. Rupp's analytical examples, three in number, involving amounts of sulphur dioxide approximating 0·0343 gr., show small errors of excess, and from them the conclusion is drawn that sulphites like arsenites, may be estimated in a solution made alkaline with sodium bicarbonate, by the process indicated.

This very unusual use of sodium thiosulphate for the determination of free iodine in the presence of an alkali bicarbonate, suggests the question as to whether the sulphite was in reality completely oxidized by the treatment, or whether the apparently good results were in fact due to a chance balancing of errors of incomplete oxidization of the sulphite, on the one hand, and on the other hand, of the excessive use of iodine in the action of the thiosulphate in an alkaline solution, it being generally supposed that in alkaline solutions not only is the expected tetrathionate formed, but that some of the thiosulphate is oxidized to the extent of forming sulphate rather than tetrathionate exclusively.

In the following table of experiments are data of experiments upon the action of iodine and sodium thiosulphate in

*Ann. Chem., ccxlii, 93. †Ber. Dtch. Chem. Ges., xxxv, 3694.

alkaline solution. The sodium thiosulphate, approximately $\frac{N}{10}$, was standardized against approximately $\frac{N}{10}$ iodine solution in a neutral solution. Varying amounts of a saturated solution of acid sodium carbonate were used to render the solution alkaline in the experiments recorded.

TABLE I.

Iodine solution = 0·01236 gr. per cm³.
Sodium thiosulphate solution = 0·01516 gr. per cm³.

No.	$Na_2S_2O_3$ nearly $\frac{N}{10}$		Iodine nearly $\frac{N}{10}$		Error in terms of I.	$NaHCO_3$	Treatment.
	cm³	I value, gr.	cm³	gr.	gr.	cm³	
1.	11·94	0·1451	15·00	0·1854	+0·0403	20	$Na_2S_2O_3$ into Iodine.
2.	11·69	0·1421	15·00	"	+0·0433	20	
3.	11·18	0·1359	15·00	"	+0·0495	40	
4.	11·25	0·1367	15·00	"	+0·0487	40	
5.	9·18	0·1116	11·00	0·1360	+0·0244	1 gr.	
6.	9·11	0·1107	11·00	"	+0·0253	1 gr.	
7.	15·00	0·1823	15·98	0·1975	+0·0152	20	Iodine into $Na_2S_2O_3$
8.	15·00	"	16·31	0·2016	+0·0193	20	
9.	15·00	"	16·62	0·2054	+0·0231	40	
10.	15·00	"	16·65	0·2058	+0·0235	40	

It is plainly evident from the table that more iodine is used up in the presence of an alkali bicarbonate, whether the iodine is run into the thiosulphate or the thiosulphate into the iodine, than accords with the theory of the reaction.

Experiments were now undertaken for the purpose of contrasting the results obtained by Rupp's procedure with results found by oxidizing the sulphite with iodine in an alkaline solution and determining the excess of iodine by standard arsenite, which, as is well known, acts with regularity upon iodine in the presence of an acid sodium carbonate. The volumes of the solutions at the time of oxidation varied from 25cm³ to 50cm³. The results are given in the following table:

TABLE II.

RUPP'S PROCEDURE.

Iodine value of SO_2 taken.	Iodine taken.	Iodine value of $Na_2S_2O_3$ taken.	$NaHCO_3$ taken.	Error in terms of Iodine.	Error in terms of SO_2
gr.	gr.	gr.	gr.	gr.	gr.
0·0977	0·2474	0·1492	1·	+0·0005	+0·0001
0·0977	0·2474	0·1454	1·	+0·0043	+0·0011
0·1440	0·2969	0·1528	1·	+0·0001	+0·0000
0·1440	0·2969	0·1518	1·	+0·0011	+0·0003
0·2759	0·4316	0·1582	1·	−0·0025	−0·0006
0·2759	0·4316	0·1628	1·	−0·0071	−0·0018

EXCESS OF IODINE DETERMINED BY STANDARD ARSENITE.

Iodine value of SO_2 taken.	Iodine taken.	Iodine value of arsenite taken.	$NaHCO_3$ taken.	Error in terms of Iodine.	Error in terms of SO_2.
gr.	gr.	gr.	gr.	gr.	gr.
0·0977	0·2495	0·1543	1·	−0·0025	−0·0006
0·0977	0·2495	0·1540	1·	−0·0022	−0·0006
0·1440	0·2984	0·1586	1·	−0·0042	−0·0010
0·1440	0·3017	0·1607	1·	−0·0030	−0·0008
0·2759	0·4354	0·1710	1·	−0·0115	−0·0029
0·2759	0·4354	0·1742	1·	−0·0147	−0·0037

From a comparison of the results in the second section of the table with those in the first section, it appears that under the conditions advocated by Rupp, the sulphite is not completely oxidized by the iodine. It seems that enough of the secondary action, by which the thiosulphate is oxidized beyond the condition of tetrathionate, takes place to counterbalance the error of incomplete oxidation when moderate amounts of sulphurous acid are handled, and more than enough for the smallest amounts, the secondary error predominating in such cases.

The results of experiments in which acid potassium carbonate was substituted for the acid sodium carbonate gave similar results.

So it appears that when Rupp's process gives results approximating the truth, it is due to the happy balancing of opposed errors. It seems quite possible that the same balancing of errors likewise occurs in the process for the determination of phosphorous acid described by Rupp and Fink.*

In conclusion, I would like to thank Prof. F. A. Gooch for many kind suggestions.

* Ber. Dtch. Chem. Ges., xxxv., 3691, 1902.

ART. XXII.—*The Billings Meteorite: A new Iron Meteorite from Southern Missouri;* by HENRY A. WARD.

A NEW siderite is now added to the six meteorites (four siderites and two aerolites) already found in the state of Missouri. The mass was found on the farm of Geo. Wolf about four miles east of Billings, Christian County, Southwestern Missouri, in breaking new ground in September, 1903. It was taken by Mr. Wolf—who considered it an iron ore,—to a street fair held in Billings in the same month, where it took the first prize as Iron Ore. The attention of J. P. Thomas was called to it, and

Billings Siderite, ¼ size.

he had a horse-shoe nail made from a piece of it and a hole drilled through the edge of the mass to test its quality. Mr. Thomas shipped it with a large number of specimens of iron ore to Kansas City, Mo., where it was bought by Mr. R. E. Bruner, a gentleman who possesses a fine collection of minerals. It remained in Mr. Bruner's hands until I obtained it from him last November.

In general shape the Billings siderite rudely resembles an axe or hatchet, as may be seen from the cut here given. Its extreme length is 15¼ inches; its greatest breadth 8¾ inches. The thickness at the larger end is 5 inches, while from the middle the mass flattens out into a blade or wedge, which is about 3 inches thick on a medium line, and slopes off to a blunt rounded edge at the sides and end. This iron has evidently

lain in the ground for a long time since its fall. Its outer surface is rusty and covered with flaking scales of oxide. There consequently remains upon its surface no sure trace of "pitting" or other aerial action incident upon its flight and fall through our atmosphere. A single circular concave depression, four inches across by one inch in greatest depth, on one side of the mass may be the remains of an original pitting on the original surface. The weight of the mass before cutting was 54 lbs. Several slices have been made under my direction which show fine Widmannstätten figures of the octahedral system. Of the structure and composition of the iron alloys inducing these figures I am indebted to Prof. Oliver C. Farrington of the Field Columbian Museum of Chicago for the remarks which follow.

The Billings iron is a coarse octahedrite (Og), with lamellæ averaging from 1–2^{mm} in width. In length many of the lam-

Section of Billings Siderite, ½ size.

ellæ extend 2^{cm} without interruption. They are as a rule comparatively straight in outline, but again become irregular and swollen and at times merge into areas where their outlines are so nearly rounded as to give a coarse-granular appearance. The substance of the lamellæ is sometimes interrupted and sometimes shows subdivision longitudinally into narrower bands by more or less continuous films of tænite. The kamacite is coarsely granular in character, and shows oriented sheen. The tænite appears as a dark, narrow line, in general bordering the kamacite, but also not infrequently crossing and anastomosing. In portions of the meteorite, where some decomposition has taken place, the tænite separates out as thin, flexible, magnetic plates of a tin-white color.

The meshes (Felder) of the section occupy but small space relatively to the bands (Balken) but are well defined where they occur. They range in size from about 25$^{sq\ mm}$ down, and in outline from triangular to trapezoidal. They are filled with a substance darker in color than the kamacite, and are

traversed by irregular numbers of delicate plates seen only under a lens, which run now in one and now in several directions. As a rule these plates start in great numbers from the borders of the mesh and thin out toward the center, but in some of the meshes they extend uniformly across. Several nodules of troilite appear in the section examined and as usual occur near its boundary. One of these nodules is irregularly oval in shape and has a diameter of about one centimeter. The others are smaller, and range in outline from nearly circular to considerably elongated. None of them has a border of swathing kamacite. A line of irregular parting extends across the section, following roughly the lamellar planes, except at about the middle of the section, where it runs nearly straight for a distance of about 2^{cm} quite irrespective of the lamellar structure. The parting at this point has a width of about one millimeter, and is filled with a substance of the section. This substance shows a foliated structure parallel with the length of the tænite, others kamacite. The structure is evidently secondary in character and appears to be a filling subsequent to the individualization of the main mass.

The chemical analysis of the iron has been made by Mr. H. W. Nichols, the chemist of the Field Columbian Museum, and is as given below:

Analysis of Billings Iron

Fe	91·99
Ni	7·38
Co	0·42
Cu	0·01
Si	0·08
P	0·15
S	0·06
	100·09

The larger part of this Billings siderite has taken its place in the Ward-Coonley Collection of Meteorites.

Chicago, Illinois.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *The Atomic Weight of Iodine.*—A series of careful determinations of this constant has been carried out by G. P. Baxter of Harvard University. The ratios of silver to silver iodide, silver to iodine, and silver iodide to silver chloride were found in making these determinations, and the average of very closely agreeing results by the three methods were 126·973, 126·977 and 126·975, where oxygen as 16 is taken as the basis. Several other investigators—Scott, Ladenburg, and Köthner and Aeuer—have recently obtained results upon the same atomic weight which agree almost exactly with those of Baxter; hence it appears certain that the atomic weight 126·85 for iodine, which has been accepted for many years on the authority of Stas and of Marignac, is somewhat lower than the truth. In spite of his wonderful skill, it seems that Stas was not quite infallible in his atomic weight determinations. The international committee on atomic weights, in the table for 1905, has adopted the value 126·97 for the atomic weight of iodine, when oxygen is 16, and the value 126·01, when hydrogen is taken as unity. Both of these numbers, it may be noticed, are curiously close to being confirmations of Prout's old hypothesis, which requires, practically, that the atomic weights should be whole numbers.—*Zeitschr. anorgan Chem.*, xliii, 14. H. L. W.

2. *Double Silicides of Aluminium.* — Manchot and Kieser have obtained the crystalline compounds Cr_2AlSi_2 and Cr_2AlSi_4 by the fusion of chromium compounds with an excess of aluminium in the presence of potassium silicofluoride, and treatment of the resulting metallic mass with an acid in order to dissolve the aluminium. The compound, Cr_2AlSi_2, forms beautiful slender crystals of hexagonal habit, which are opaque, with a strong metallic luster and white color. The compound is very inactive with most chemical agents. It is insoluble in acids, except hydrofluoric acid; it remains bright when heated in a stream of oxygen, and is not attacked by fusion with potassium bisulphate; but it readily decomposes by fusing with alkalies. The other compound was obtained in a similar way in the presence of a larger amount of silicon. It forms smaller crystals, is somewhat harder, but otherwise it is like the first compound in its properties. These compounds are the first double silicides to be described.—*Ann. der Chem.*, cccxxxvii, 353. H. L. W.

3. *Europeum.*—This element, occurring in very small quantities among the rare earths and coming between samarium and gadolinium, was described by Demarçay several years ago. Urbain and Lacombe have recently confirmed the existence of the earth. They used 610 g. of oxides representing the whole of the europeum group of earths from about 500 kilos of monazite

sand, and by a long series of fractionations involving some 3000 crystallizations, they obtained several fractions of constant properties and atomic weight, apparently consisting of pure europeum. The amounts obtained indicated that the monazite sand contained about two hundred-thousandths of europeum oxide. The sulphate has a scarcely visible rose tint, while the oxide prepared at a low temperature is practically white, although when intensely ignited it is distinctly rose-colored. Closely agreeing atomic weight determinations made with several different fractions gave 151·79 as the result, which the authors believe to be true within ·06. Demarçay had given the atomic weight as about 151.—*Comptes Rendus*, cxxxviii, 628. H. L. W.

4. *The Use of Calcium Carbide as an Explosive in Mining.*—Guédras has described a method of utilizing the explosive force of acetylene for mining purposes. A sheet-iron cylinder is used as a cartridge. At its bottom are placed about 50 g. of granulated calcium carbide, and above this in a separate compartment is a sufficient amount of water to react with the carbide. There is also an air-chamber containing an electric fuse. The cartridge is placed in the hole to be exploded, the latter is closed with a wooden plug, and an iron rod attached to cartridge for the purpose of piercing the water compartment is struck, thus liberating the acetylene. After this has been disengaged for about five minutes, the mixture of air and acetylene is exploded. The explosion causes the rocks to fly about much less than would be expected, but they are thoroughly broken up.—*Comptes Rendus*, cxxxix, 1225. H. L. W.

5. *Silicon-fluoroform.*—The silicon compound, $SiHCl_3$, silicon-chloroform, is well known, and recently Ruff and Albert, by allowing the compound just mentioned to act upon tin tetrafluoride or titanium tetrafluoride, have succeeded in obtaining the corresponding fluorine compound. Silicon-fluoroform is a combustible gas which liquefies at atmospheric pressure at about $-90°$ and solidifies at about $-110°$. It is decomposed by water and alkaline solutions without change of volume, for the hydrogen produced by the decomposition is equal in volume to the original gas, as is evident from the following equations :

$$SiHF_3 + 3NaOH + H_2O = Si(OH)_4 + 3NaF + H_2;$$
$$2SiHF_3 + 4H_2O = Si(OH)_4 + H_2SiF_6 + 2H_2.$$

The preparation of the compound under consideration completes the series $SiHF_3$, $SiHCl_3$, $SiHBr_3$, and $SiHI_3$ of analogous halogen compounds.—*Berichte*, xxxviii, 53. H. L. W.

6. *Double Cyanides of Copper.* — A considerable number of these double salts has been prepared and studied by Grossmann and von der Forst. They are all cuprous salts, and contain lithium, sodium, potassium, rubidium, cæsium, as well as ammonium, calcium, strontium, and barium. Five different types of double salts were noticed ; for instance, omitting water of crystallization, I. $KCu_2(CN)_3$, II. $Rb_2Cu_3(CN)_5$, III. $KCu(CN)_2$, IV.

$Na_2Cu(CN)_3$, V. $K_3Cu(CN)_4$. The salts of type III were obtained in the largest number. It may be mentioned that all of these types occur among the known cuprous double chlorides.—*Zeitschr. anorg. Chem.*, xliii, 94. H. L. W.

7. *An Occurrence of Radium and Radio-active Earths.*—F. GIESEL has found that mud from Fango and soil from Capri possess an activity of about one one-thousandth of that of pitchblende, and that it is possible to extract radio-active products from them by chemical methods. For instance, from 40 kg. of the Capri soil about half a gram of barium bromide was extracted, which showed distinct spontaneous phosphorescence upon dehydration. In neither of the materials could uranium be detected.—*Berichte*, xxxviii, 132. H. L. W.

8. *N-Rays.*—E. GEHRCKE describes at length certain hallucinations which might arise in the investigation of the so-called N-rays. He finds that any object, the forefinger for instance, moved to and fro behind a phosphorescent screen produced a change in the light of the screen. The effect is not produced if an independent observer moves the object; and it is therefore a psychological one. The author believes that the phenomenon is analogous to many which arise at the extreme limit of vision. For instance one often believes that he sees a faint image while developing a photographic plate when no such image really exists. The author does not attempt to explain the photographs obtained by Blondlot and he remarks that in whatever way the phenomena of N-rays may be explained, Blondlot has rendered a service in calling attention to interesting phenomena.—*Physikalische Zeitschrift*, No. 1, Jan. 1, 1905, p. 7–8. J. T.

9. *Photography of N-rays.* — G. WEISS and L. BULL have failed to obtain such registration, and remark that Blondlot now concludes that the rays increase or affect visibility and not luminosity.—*Comptes Rendus*, cxxxix, Dec. 12, 1904, pp. 1028–1029. J. T.

10. *Spectra of Electric Discharges in Cooled Geissler Tubes.*—E. GOLDSTEIN describes the distribution of light and the spectra produced by suddenly immersing Geissler tubes in liquid air. The method appears to be of use in obtaining the spectra of metals in great intensity and with sharp lines. It also reveals a difference in the cathode light, according to the kind and nature of the cathode.—*Physikalische Zeitschrift*, No. 1, Jan. 1, 1905, pp. 14–17. J. T.

11. *The Dependence of the Ultra-Red Spectrum of Carbonic Acid upon Pressure.*—CLEMENS SCHAEFER concludes from his investigation on this subject that Arrhenius' theory in regard to the ice age is erroneous. The latter concluded from his figures that a diminution of the amount of carbonic acid in the earth's atmosphere would lead to a fall of temperature of the earth, and in consequence of diminished absorption there would be an increased radiation of heat from the earth into space. Thus an ice age might have been caused. Schaefer shows that the con-

clusion that variation in thickness of layer and variation in pressure have similar effect upon absorption is not justified. Changes of volume amount of CO_2 have no influence on the earth's temperature so long as the diminution of carbonic acid remains under 80 per cent of the former quantity.—*Ann. der Phys.*, No. 1, 1905, pp. 93–105. J. T.

12. *Electromagnetic Waves in the Visible Spectrum.*—Many attempts have been made to identify these waves with light waves. FERDINAND BRAUN forms suitable resonators or "Gitters" by deflagrating very fine wires stretched on glass plates; and then observing changes of polarization by means of suitable optical devices directed upon the particles of finely divided metal. According to the electromagnetic theory these "Gitters" should allow little light through if the arrangements of the particles are parallel to the electric vector, and much if they are perpendicular to it. The author believes that his photographs show a complete analogy between Hertz waves and optical waves. He shows also that the method he employed is of importance in mineralogical work.—*Ann. der Phys.*, No. 1, 1905, pp. 1–19. J. T.

13. *Damping Galvanometer Deflections.*—W. EINTHOVEN continuing his investigations on his new galvanometer, which consists of a silvered quartz fiber stretched in a strong magnetic field, finds that a condenser attached to the terminals of the fiber is of great use in bringing the oscillations to rest even when they are extremely rapid. It is believed that the method will be of great advantage in acoustical investigations and also in physiological work.—*Ann. der Phys.*, No. 1, 1905, pp. 20–31. J. T.

14. *Possible variation in Solar Radiation.*—The report of S. P. Langley, Secretary of the Smithsonian Institution, for the year ending June 30, 1904 (noticed on p. 260), contains in the statement of the work accomplished at the Astrophysical Observatory, under the charge of C. G. Abbot, a further discussion of the possible variability of the sun first rated in the report of the year preceding. We quote the following paragraphs:

"Notable progress has been made with the researches you have initiated on the amount of solar radiation and its absorption in the solar envelope and in our atmosphere. Within the last seventeen months three independent kinds of evidence have been collected here, pointing toward the conclusion that the radiation supplied by the sun may perhaps fluctuate within intervals of a few months through ranges of nearly or quite 10 per cent, and that these fluctuations of solar radiation may cause changes of temperature of several degrees centigrade nearly simultaneously over the great continental areas of the world. Further evidence must, however, be awaited to verify this important conclusion.

The three kinds of evidence referred to are as follows: First, on all favorable days the 'solar constant' of radiation outside our atmosphere has been determined here, and changes of about 10 per cent in the values obtained have been found which cannot be attributed to known causes. Second, the solar image formed by

the horizontal telescope has been examined with the spectrobolometer to determine the absorption of radiation within the solar envelope itself. If we grant for argument's sake that the rate of solar radiation outside our atmosphere fluctuates rapidly from time to time, then as you have observed, the cause of this fluctuation cannot reasonably be a variability of the temperature of so immense a body as the sun itself, but must rather be in a change in the absorption of a more or less opaque envelope surrounding the sun. Accordingly the two researches I have mentioned are intimately associated, for if we find a considerable increase in the rate of solar radiation outside our atmosphere we ought to find a corresponding decrease in the absorbing power of the solar envelope.

Such is in fact one of the most notable results of the year's work. In August, September, and October, 1903, the observations of the 'solar constant' of radiation indicated that the rate of radiation was about 10 per cent below that observed in February, 1904. On the other hand, measurements of the absorption of the solar envelope indicated considerably less absorption in February, 1904, than in September, 1903.

The third kind of evidence of change in solar radiation is based on a study of the temperature of the North Temperate Zone, as indicated by the Internationale Dekadenberichte published by the Kaiserliche Marine Deutsche Seewarte, and received at the Observatory through the kindness of the Librarian of the United States Weather Bureau. This publication gives the mean temperature at 8 A. M. for each ten days at each one of about one hundred stations distributed over the principal land areas of the North Temperate Zone, and for about ninety of these stations there is also given the normal temperatures for the same ten-day periods, representing the mean of many years. From these data there have been computed here the temperature departures from the normal since January 1, 1903, and these are compared graphically in the accompanying chart, Plate VII,* with the measures of the solar constant made in 1903. It will be seen that shortly after the observed fall of solar radiation in March, 1903, a general fall of temperature occurred, which would be a natural result of such a change. It has been shown here, in accordance with the known laws of radiation, that 10 per cent fall in the solar radiation could not produce more than 7°·5 C. fall in terrestrial temperatures, and that several causes, notably the presence of the oceans, would prevent so great a change of temperature as this resulting from a temporary diminution of solar radiation of only a few months' duration. The observed fall of about 2°·5 C. in the mean temperature of the land areas of the North Temperature Zone during April, 1903, seems to be therefore in good accord with the observations of solar radiation.

Owing to the uncommon cloudiness of the first six months of

* Shown also in your article on "A Possible Variation of the Solar Radiation," Astrophysical Journal, June, 1904.

1904 few measures of the 'solar constant' worthy to be compared with the series of 1903 have been obtained, but taking the best of the measures it appears that high values of solar radiation in February, 1904, and lower ones in the subsequent months are indicated, as shown in Table II, given below. This appears to be in general accord with the mean temperature observed over the North Temperate Zone, except that it seems probable that the solar radiation was high in January as well as February, but the lack of good observing weather prevented our recognition of it."

The importance of this subject is remarked upon in its bearing upon forecasts of temperature, in case further research serves to confirm the indications now obtained as to a general parallelism between measures of solar radiation and terrestrial temperature. For this work, however, a better station for observation than Washington is needed.

15. *Terrestrial Magnetism. Results of Magnetic Observations made by the Coast and Geodetic Survey between July 1, 1903, and June 30, 1904;* by L. A. BAUER. Appendix No. 3, Report for 1904. Washington, 1904.—This report* contains the usual detailed statement of magnetic observations made in the United States and outlying territories during the year ending June 30, 1904; an interesting feature is the introduction of observations made at sea by the Survey vessels, this is a new departure begun in February, 1903. In the introductory summary of results reached some interesting notes are made, particularly in regard to the changes of magnetic declination in Louisiana. We quote some paragraphs:

"The results of this detailed work in Louisiana have been extremely interesting. First, it has been clearly demonstrated that there was a reversal in the expected course of the secular variation which took place about 1898. Past observations made in the vicinity of New Orleans show that the magnetic declination, which is east, reached a maximum amount of about $8\frac{3}{4}°$ near the year 1830. It then began to diminish, and, in accordance with the laws of the secular variation pertaining north and east of the agonic line, i. e., in the Atlantic States, where west declination is known to be increasing at present on the average about three minutes per year, a turning point was under ordinary conditions not to be expected before some time about the middle of the present century. Instead, however, it was reached about 1898, so that east declination reached a minimum value of $5\frac{1}{2}°$ in about seven decades after a maximum value—the shortest interval between a maximum and a minimum value thus far revealed anywhere on the earth. East declination is now increasing in Louisiana at the rate of about one and one-half to two minutes per annum. The total change between maximum and minimum at New Orleans, as above stated, was about $3\frac{1}{4}°$.

The early reversal produced a larger annual change between the years 1860 and 1870—about six minutes—than has generally been experienced in the United States, although elsewhere, as, for

* See also p. 261.

example, England, such large annual changes and even greater ones occur. Values of the magnetic declination secured four to five decades ago, if referred to the present time with the aid of secular change values as were expected, in accordance with the experience in other parts of the United States, would be in error one-third to one-half degree.

Observations in other States near Louisiana show that this change in the course of the secular variation is manifesting itself in greater or less degree, according to locality, likewise in these States. How permanent the present change may be, i. e., whether it will continue for but a comparatively short period, so that before long another reversal may be expected, after which east declination will begin to diminish once more, can not be stated at present.

The magnetic survey of Louisiana has revealed other most interesting features, as shown by the lines of equal magnetic declination, dip, and horizontal intensity, drawn in conformity with the observations. There were noticed marked relations with well-known physiographic features. The curvatures and bendings of the lines of equal magnetic declination appear to conform with courses of principal steams and shore lines of certain bodies of water. Also a marked difference manifested itself in the general direction of these lines in the middle of the southern part of the State, just where there is a dividing line between the newer and older geological formations.

It is especially interesting that the irregularities in the distribution of the earth's magnetism, as exhibited by the three sets of lines, occur chiefly in the regions of the alluvial deposits brought down by the Missisippi River. Owing to these irregularities the compass needle is deflected from the direction it would ordinarily have assumed by amounts varying from about 0°·1 to 0°·5. They are not local disturbances of such amount which ordinary instruments would readily reveal, but they are of such a magnitude as only approved instruments and methods would indisputably expose. This point can not be emphasized too strongly for the sake of geologists who undertake to discover relations between magnetic disturbances and geological formations, employing crude instruments, and using imperfect methods.

Quite likely these irregularities are to be referred to small local deposits of iron ore brought down from the upper States by the Mississippi River."

16. *An Introduction to the Study of Spectrum Analysis;* by W. Marshall Watts. Pp. vii, 325, 8vo. London and New York, 1904 (Longmans, Green & Co.).—The first impression from a hasty inspection of this work is the extraordinary variation in the character and value of the numerous illustrations contained in it. We recognize some cuts which are familiar in popular works on spectroscopy from as early a date as 1870, and which might have been omitted even then with profit to the reader. A number of those illustrating the very primitive treatment of the

optical theory of the spectroscope are subject to this criticism; and fig. 15, intended to show the path of the light through a powerful prism spectroscope, could hardly be modified so as to give more hopelessly false ideas as to the optical principles involved. A critical reading shows an analogous lack of uniformity in the unexpected relative importance attaching to the different topics treated. Probably few spectroscopists would approve the ratio of eight pages devoted to absorption spectra to only two appropriated to the explanation and application of Doppler's principle. A single page is given to the subject of spectroscopic binaries, of which o Ceti and β Cygni (with relative magnitudes reversed) are cited as examples. It would be difficult to imagine errors which would be more confusing to a beginner. This is immediately followed by more than six pages on the spectra of comets. Another peculiarity is an utter lack of system in the orientation of cuts representing spectra. In many, the wave-lengths decrease from left to right, while in the others the reverse order is employed; nor is it always easy to tell, either from the figure or from the text, which arrangement is selected.

On the other hand, there are features which will make the book a welcome addition to every scientific library. The copious references to sources and the extended tables of spectra at the end of the volume will certainly prove conveniences. Then, too, the chapter on the Michelson Echelon spectroscope is so satisfactory that one wonders why the important theory of the concave grating is wholly neglected. C. S. H.

17. *The Reflecting Telescope.* From Vol. XXXIV of Smithsonian Contributions to Knowledge.—This publication consists of two parts, the first of which is a reprint of the celebrated paper by Professor Henry Draper, On the Construction of a Silvered Glass Telescope, published in 1864 in Vol. XIV of the same series. This is so well known to all amateur and working opticians that a review of it here is quite unnecessary. The second part, of nearly the same length, bears the title, On the Modern Reflecting Telescope and the Making and Testing of Optical Mirrors, by George W. Ritchie of the Yerkes Observatory. This is a highly interesting description of the refined methods which have been gradually introduced during the forty years which have lapsed since the appearance of the earlier paper, illustrated especially by the experience of its author in constructing 24- and 60-inch parabolic mirrors in the optical shop of the Yerkes Observatory. The frontispiece is an enlargement of the admirable photograph of the central portion of the Great Nebula in Andromeda, taken by Mr. Ritchie with the 24-inch mirror. A comparison of the illustrations of the two papers—both of the highest excellence attainable at their respective periods—is most instructive. C. S. H.

18. *An Introduction to the Theory of Optics;* by Arthur Schuster. Pp. xv, 340. London, 1804 (Edward Arnold).—This is a notable addition to the literature on optics. The first

two hundred pages are occupied with a general description of the phenomena of optics with their mathematical theory. Chapters IV, V and VI, on interference of light, diffraction, and diffraction gratings, respectively, are especially good. The chapter on the theory of optical instruments, however, leaves much to be desired; the theory of the microscope is not touched upon, and a theory of the telescope, which leads to the conclusion that a magnification of eight to the inch of aperture of the objective quite exhausts its resolving power for an eye free from spherical aberration, is necessarily erroneous.

Part II, on modern theories of light, of dispersion and absorption, and of the relations of optical to electromagnetic phenomena, containing all that is very recent in optical science, is of greater value and interest. A careful reading of this portion is certain to be profitable to every student of physics. The treatment of Talbot's Bands (p. 329) may be cited as specially interesting and suggestive.

The illustrations of the work are not wholly satisfactory, with the exception of its two plates which are reproductions of direct photographs of interference phenomena. Unfortunately, the references in the text to these plates contain many errors which would prove very confusing to one not already familiar with the phenomena. We may add that the first figure on Plate I, showing the interference bands formed by a biprism, owes its irregularities to a defective prism, not, as is asserted in the text, to the periodic nature of light itself. C. S. H.

19. *Das Elektrische Bogenlicht; seine Entwickelung und seine physikalischen Grundlagen;* von W. B. VON CZUDNOCHOWSKI. Erste Lieferung, pp. viii, 98. Leipzig, 1904 (S. Hirzel).—The first part of this work upon the electric arc light was issued some months since and is largely devoted to the physical side of the subject. The entire work is to be published in six similar parts, and from what we have before us may be expected to satisfy all demands as to fulness of description and illustration.

II. GEOLOGY AND MINERALOGY.

1. *A Treaties on Metamorphism;* by CHARLES RICHARD VAN HISE, U. S. Geological Survey, Monograph XLVII, 1286 pp., 13 pl., 32 figs.—Professor Van Hise's Treatise on Metamorphism will undoubtedly take rank as one of the most important single publications ever issued by the Geological Survey. The volume is the outcome of a life-long study in the province of metamorphic geology. Partial views have been published in his earlier papers, and the ground work of metamorphism has, of course, been gradually established through the labors of many leaders in geology during the past century. Nevertheless the subject is doubtless indebted to Van Hise more than to any other one individual for its reduction to an exact science. In the present treatise a highly successful attempt has been made to arrange the

phenomena of metamorphism in order and to show how they are throughout the expression of chemical and physical laws operating within the crust of the earth.

The earliest stage of science is largely descriptive, qualitative and speculative. The branch of metamorphic geology may now be said to have fully passed through such a preliminary stage and to have entered upon its final development. Although many able works have appeared in the past this treatise must be looked upon as the landmark of a new era, a starting point from which further studies will largely take their departure. Following these introductory statements the volume itself may be described.

In the introductory chapter it is shown that a great difficulty in studying metamorphism arises from the fact that many of the changes take place under conditions which cannot be directly observed, so that the forces and agents accomplishing certain results must be inferred from the nature of the results. This method is directly the opposite of that which has usually been applied to the elucidation of surface geology, and this fact gives the peculiar difficulty to the deeper problems of metamorphism and has retarded its development to a period later than that of any other branch of the science.

Under metamorphism is embraced not only the changes which take place in the deeper parts of the lithosphere but surface alterations as well, so that the treatise covers a large part of the ground of the older treatises on chemical and physical geology.

It appears that the processes of metamorphism, using the term in this inclusive manner, come under surprisingly few heads. The upper zone, characterized by hydration, oxidation, carbonation, resulting in expansion of volume and production of heat, tends to break down complex mineral molecules into a few of relatively simple composition and, following the analogy of the term of katabolism in biology, the zone is called the *zone of katamorphism* ("kata" meaning tearing down). This zone is divided into a *belt of weathering* extending to the level of ground water and below this a *belt of cementation*, within which is deposited much of the silica and other substances carried downward from the belt of weathering.

The zone of katamorphism corresponds roughly with the zone of fracture. Below this pressure due to gravity becomes the dominant factor in reactions. Complex compounds whose formation is attended by contraction of volume result from more simple ones. The reactions are characterized by a tendency to dehydration and decarbonation where water or carbonic acid is present. Again, following the analogy from biology, this zone, in which complex molecules are built up, is named the zone of anamorphism (from "ana" meaning a "building up"), and corresponds in general with the zone of flowage, the one term expressing the character of the chemical and mineralogical changes, the other the character of the mass deformations.

In both zones it is believed that the total reactions involve the

liberation of heat, in the outer zone from chemical reaction, in the inner from reduction of volume; and thus metamorphism conforms to the apparent law of the universe of dissipation of energy.

Chapter II treats in detail of the forces of metamorphism; chemical energy, gravity, heat, and light. Chapter III of the agents, which are gaseous and aqueous solutions and organisms.

Of great use to the working geologist and mineralogist is chapter V, which treats individually of the geological relationships, genesis and alterations of each of the rock-making minerals. The alterations are ordinarily such as take place in the zone of katamorphism, but the author points out that upon the altered materials being brought again into the zone of anamorphism the reactions are reversible and, provided that the results of decomposition are present in suitable proportions, the original mineral may be reproduced. Some of the more complicated reactions have been written out chemically for the first time, and, as pointed out by Van Hise, must be looked upon as first approximations and suggestive for further study.

The following three chapters, VI, VII, VIII, treat in detail of the belt of weathering, the belt of cementation and the zone of anamorphism. In regard to the belt of weathering besides a statement of the laws governing the changes a number of new features are developed, but special emphasis is placed on systematization under laws of physics and chemistry, of a vast number of facts already known.

In chapter VIII, among other matters are treated the meaning and method of rock flowage, the generalization being arrived at that rock flow is mainly accomplished through continuous solution and deposition, that is, by recrystallization of the rocks through the agency of the contained water, the rocks throughout, with the exception of an inappreciable amount which at the moment is in solution, being crystallized solids.

The student of metamorphic geology is expected as a matter of course to study carefully the entire monograph and a review should hardly be written for him, but rather for the general student of geology.

To such, perhaps, the most interesting chapter is the eleventh, upon *the relations of metamorphism to the distribution of the chemical elements*, and a more extensive review of this chapter will therefore be given.

Metamorphic processes operating upon the lithosphere have redistributed the elements of the original igneous rocks tending to segregate them into the several groups of sedimentary rocks, the hydrosphere and atmosphere, this redistribution concerning many large questions of geological theory. The author states,—"So far as practicable redistribution is dealt with in a quantitative way, . . . made more with a view of stating the various problems which in the future will undoubtedly be satisfactorily

treated quantitatively rather than with the belief that the calculations given even approach accuracy. Indeed this chapter is no more than an attempt to blaze a trail in the wilderness."

The author then considers the average composition of the lithosphere, the sedimentary rocks, the hydrosphere and atmosphere, using the work of F. W. Clarke, Dittmar and Farrington. The sedimentary rocks with certain portions of the hydrosphere and atmosphere, if recombined should give the average composition of the igneous rocks from which they were originally derived, and as a first approximation the shales are estimated at 0·65, the sandstones 0·30, and the limestones 0·05 of the sedimentary rocks; and the average thickness of the latter upon the surface of the continents which have always remained within the zone of katamorphism is estimated at two kilometers, this being less than has usually been estimated.

The results indicate that this relative proportion of the sediments must be in the neighborhood of the truth. In regard to the thickness of the sediments, however, Van Hise is inclined to think that even the moderate estimate of two kilometers may be too great. By assuming a smaller thickness, however, the character of the results would not be changed but only the absolute amounts of the surpluses and deficiencies. From these data some surprising results are obtained. To oxidize the ferrous iron of the igneous recks to the ferric state in which it is usually found in the sediments would require 35 per cent of the oxygen now in the atmosphere. The further oxidation of the metals and the sulphur united as sulphides in the original rocks would require twice the oxygen now in the atmosphere. Further quantities have been consumed in the formation of nitrates. "In summary it appears that the chief certain source of oxygen for the atmosphere is the reduction of carbon dioxide by vegetation and the burial of a part of this vegetation in the earth. This source is vast in amount. On the other hand . . . the oxygen consumed during geological time . . . has been enormous. It probably vastly exceeds the amount which has been liberated to the atmosphere by the reduction of carbonic acid through plants."

"If this conclusion be correct, such wild guesses as those of Koene and Phipson, that the carbon dioxide of the original atmosphere greatly exceeded the oxygen and that the proportions of these elements have been reversed in consequence of the reduction of carbon dioxide by organic matter, are wholly unwarranted."

Under *sulphur*, it is shown that the proportion of sulphur in the secondary rocks and ocean is more than four times as great as in the original igneous rocks. It is thought highly probable that the discrepancy is largely explained by the actual escape of much sulphur as a gas during periods of volcanism, the igneous rocks containing only the residual sulphur which separated as a sulphide when the magma crystallized. The same explanation probably applies to a similar excess of carbon and chlorine.

It is found that silica shows an excess of 3·2 per cent in the secondary rocks and alumina a deficiency of 3·7 per cent. The author suspects that this discrepancy is largely due to errors in the determination of the silica and alumina in the analyses of shales.

Some of the general conclusions in regard to carbon are already somewhat familiar through the work of Chamberlin and others, the amount which is locked up in the sedimentary rocks being estimated at many hundred times that contained in both the atmosphere and hydrosphere.

"The chief processes which abstract carbon dioxide from the atmosphere are those of carbonation and the building up of carbonaceous deposits. All the replenishing processes, including the reversing processes of silication and the oxidation of buried carbon compounds, have been barely able to keep a minute portion of the carbon dioxide in the atmosphere. . . . It is probable however that the work of man, especially during the last half century, has returned a great volume of carbon dioxide to the atmosphere by the artificial oxidation of carbonaceous material, and thus has reversed the average of the processes of nature, which plainly appear to have caused depletion of the carbon dioxide in the atmosphere. In consequence, at the present time the amount of carbon dioxide in the atmosphere may be increasing rather than decreasing."

In treating of the alkalies it is shown that the amount of potassium in the sedimentary rocks and the ocean agrees fairly well with the proportions in the original igneous rocks. In the case of sodium, however, there is a remarkable deficiency in the sedimentary rocks, and even when the salt of the ocean is added the total sodium reaches a proportion not more than one-third of that in the original rocks.

"It is, therefore, plain that we must turn to some other direction to account for the great deficiency of sodium in the ordinary sedimentary rocks. The natural direction to which to turn is to the salt deposits of the world. . . .

"From the foregoing it appears highly probable that we must look to the salt deposits and to the alkaline deposits of arid regions to explain the great deficiency of sodium in the ordinary sediments rather than to the ocean. If this conclusion be correct, calculations upon the age of the earth have no value which are based upon the derivation of salt from the land through weathering processes and its accumulation in the sea, and which ignore or place as relatively unimportant the salt deposits of the land."

The final chapter of 240 pages deals with ore deposits and is an amplification and further systematization of the papers already published by the author in the Transactions of the American Institute of Mining Engineers. Special emphasis is placed on the application to ore deposits of all laws developed for metamorphism in general.

The foregoing pages of this review have served to give some

idea of the breadth and depth of this treatise. In conclusion it may be said that the general student will find here in the most systematized and digested form a vast mass of facts and principles dealing with chemical and physical geology. All students of geology should gain some familiarity with its contents, and to the specialist in metamorphism it must become a volume of constant study and reference. J. B.

2. *The United States Geological Survey*, Twenty-Fifth Annual Report, 1903–'04, 371 pp., 25 pls., 2 figs.—The United States Geological Survey has reached its quarter-century anniversary and the director gives a brief outline of the results accomplished during the twenty-five years of the Survey's existence. A complete topographic map of 929,850 square miles of the United States, including Alaska, has been made during this time, which amounts to 31 per cent of the area of the country, excluding Alaska. The Survey has been particularly helpful in investigation of the origin and geologic relations of ore deposits; and the results of this work in Leadville and the Lake Superior region are alone sufficient to justify the generous appropriation now granted by congress. The first appropriation for the Survey amounted to $106,000. The total appropriated in 1903–'04 was $1,377,820. During recent years the qualitative standard of the work has been much raised; greater accuracy and higher literary quality characterize the recent papers published by the Survey. Eleven states now coöperate with the government in topographic surveys, and topography still claims the larger share of the annual appropriation.

The section of Pleistocene Geology has been renamed the section of Physiography and Glacial geology and placed in charge of G. K. Gilbert. This new division is in distinct recognition of the geographical aspects of geology, and the importance of ice as a geologic agent. The work in Alaska has received greater attention than ever before, and the geographic and geologic publications in that section show the development of one of the most remarkable pieces of scientific exploration ever attempted. The reclamation service reports rapid advance in many of the western states, and during the year actual construction was begun on the Salt River project in Arizona and the Truckee-Carson project in Nevada. The division of chemistry and physics is conducting important researches along new lines and it is gratifying to see that the work is sufficiently recognized as to receive largely increased appropriations.

3. *Geology of Perry Basin in Southeastern Maine;* by George Otis Smith and David White. United States Geological Survey, Professional Paper No. 35, 102 pp., 6 pls.—The Perry Basin has excited the interest of geologists ever since the formations were first described by Jackson in 1836, and a great deal of difference of opinion has existed regarding the origin and age of the strata here exposed. The formation is now shown to be "distinctly Devonian and probably Chemung." It consists of

brownish conglomerates with interbedded lavas lying unconformably on earlier formations.

The present investigation was undertaken jointly by the United States Geological Survey and the State of Maine in a search for coal, and ten days of field work were sufficient to amply prove that there is no geological evidence to support the belief that coal exists in this region. This investigation brings clearly to light the value of geologic work. For the last seventy years there has been a persistent belief that coal could be obtained in the district about Passamaquoddy Bay, and shafts and drill holes have been put down at considerable expense at different times. This persistent myth has led the public astray and shows how ready the average man is to accept favorable rather than unfavorable reports. At a small expense the question of coal in Maine has been settled once for all and might have been equally as well settled fifty years ago if it had been so desired.

In addition to newly discovered plant remains Dr. White has studied the collections in American museums, and his present descriptions and figures constitute a fairly complete study of the Perry fauna.

4. *Preliminary Report on the Arbuckle and Wichita Mountains of Indian Territory and Oklahoma;* by Jos. A. Taff: with an appendix on *Reported Ore Deposits;* by H. Foster Bain. United States Geological Survey, Professional Paper No. 31, 93 pp., 8 pls., 1 fig.—Very little has been heretofore known regarding these interesting mountain areas lying west of the main Ozark uplift. The Arbuckle Mountains consist of a great thickness of rock chiefly limestone, from Middle Cambrian to Devonian, overlaid by Carboniferous conglomerates, shales, and sandstones. The central part of the district, unconformably beneath the Cambrian strata, is a mass of granite, granite porphyry, diabase, and associated crystalline rocks. The mountains date from Middle Carboniferous, but were worn down before the end of Carboniferous time. Folding and faulting occurred during all Carboniferous, and there is no record of sedimentation between the Permian and Cretaceous. Peneplanation occurred in Cretaceous time and also in Tertiary, when the region was reduced practically to sea-level. The structure of the mountains has been worked out in detail and shows a number of well-developed anticlines and synclines.

The Wichita Mountains are a new field of study and consist of a collection of mountains, hills, and knobs extending for a distance of 65 miles. The mountain region is symmetrical in general outlines; but the arrangement, size, and forms of individual masses are remarkably various and rise from the nearly level smooth plain of the "red-beds" as so many islands. The mountains proper and most of their outlying groups consist of granite, granite porphyry, and gabbro. These igneous rocks are separated into more than 250 detached areas, and this archipelago-like arrangement of the granite peaks seems to indicate that but a

small part of the igneous core of the Wichita uplift is now exposed. The rock section of the Wichita Mountains is almost an exact reproduction both in stratigraphy and structure of the Arbuckle Mountain uplift, and the epochs of its stratigraphic history probably also correspond with those in the mountains to the east.

5. *The Oldest Sedimentary Rocks of the Transvaal.* — In a recent paper by FREDERICK H. HATCH, published in the Transactions of the Geological Society of South Africa, vol. vii, pt. 3, attention is called to the discovery of metamorphosed sediments of earlier age than the Witwatersrand series. The rock is variable in character. One of its stricking features in the Mt. Marais district is the presence of "knotted" schist containing andalusite and ottrelite. This early formation has been named the Swaziland series and, with its intrusive granite, is ascribed to the Archean system. Swaziland beds occupy the same relative position as the Malmesbury beds of Cape Colony.

A paper by E. J. T. JORISSEN, read December 12th, before the Geological Society of South Africa, gives a detailed description of the granites which are intruded in the Swaziland beds, and underlying unconformably the Witwatersrand.

6. *Maryland Geological Survey. Miocene*, text, pp. i–clv, 1–543; volume of plates, x–cxxxv. The Johns Hopkins University, 1904.—These two splendid volumes treat of the stratigraphy and life of the Miocene deposits of Maryland. The stratigraphy is described by Clark, Shattuck, and Dall. The fauna and flora are described in detail and illustrated by excellent drawings, as follows: The plants, by Hollick and Boyer; vertebrates, by Case and Eastman; the bivalves, by Glenn; the other Mollusca, the brachiopods, and most of the Crustacea, by Martin; the ostracods and bryozoans, by Ulrich and Bassler; the echinoderms, by Clark; the corals, by Vaughan; the foraminifers, by Bagg. The number of fossil species is large, as 652 are described.

The State Geologist reports that the "most important contribution to the interpretation of the Maryland Miocene deposits which has been hitherto made" is by Dr. Dall. On pages cxxxix–clv, Dall discusses "The relations of the Miocene of Maryland to that of other regions and to the recent fauna." The Maryland Miocene is divided into Calvert, Choptank, and St. Mary's formations. "One-third of the molluscan fauna of the Maryland Chesapeake is peculiar to it. Ten per cent survive to the present fauna."

"The temperature conditions governing the fauna of the Maryland Chesapeake were those of the temperate rather than the boreal or subtropical faunas of the present coast; and . . . the temperature of the Chesapeake embayment was on the whole somewhat warmer than at present."

"In a general way, allowing for local peculiarities, the Miocene fauna of North Germany compares well and agrees closely with

that of Maryland, while the Mediterranean Miocene finds a closer analogue in the more tropical fauna of the Duplin beds of the Carolinas."

These volumes should be in the hands not only of stratigraphers and paleontologists, but of all teachers of historical geology as well, for here is given not only a detailed description of the Maryland Miocene stratigraphy and its preserved organic remains, but also the relationship of these faunas to those of other areas of North America and of Europe. The State of Maryland is to be congratulated on its able and active survey staff, under the efficient leadership of Professor W. B. Clark. Among state surveys it stands second, ranking next to that of the rich state of New York. C. S.

7. *Palæontologia Universalis.* — The third fasciculus of this important republication of old or obscure species of fossil organisms has arrived. These three parts treat of 75 species, figured and described in 161 sheets. This completes the first annual subscription, which is eight dollars. The first fasciculus of the second series will soon appear, and subscriptions should be sent to G. E. Stechert and Co., 129–133 West 20th street, New York City. The editorial work is in the hands of D.-P. Œhlert, of Laval, France, Secretary to the International Commission appointed by the International Geological Congress, at its eighth meeting. C. S.

8. *On the Melting Points of Minerals.* — M. A. Brun has recently published a second memoir on the subject of the fusion of minerals, which was first discussed by him in 1902.* The object of the present investigation has been to establish the melting point of the feldspars and some other important minerals (leucite, chrysolite, wollastonite), both in the crystalline and glassy states. The results now obtained are summarized by the author as follows:

"The present work will serve to control scientifically the values previously given, and, also, to establish the melting points of the *colloids*, which have the same percentage composition as the crystals.

The measures have been taken with the help of the calorimeter. A large block of platinum was used as thermometer and Viole's rule was used for the calculation of the temperature.

The results of these experiments prove that the figures published in 1902 are exact. They therefore agree with the figures given for the *crystals*. It is shown, moreover, that in the complete thermic study of the silicates, the following points should be determined.

(*a*) The melting temperature of the *crystal*. (*b*) The melting and softening temperature of the *colloid* (glass) which has the same percentage composition. (*c*) The temperature needed to bring about the crystallization of colloids. (*d*) The temperature

* Arch. des Sc. phys. et nat. (4), xiii, April, 1902. See also the paper by Day and Allen in the February number of this Journal.

of the point of the agglomeration into a mass of powder such as: chrysolite, kaolin, zircon.

There are great differences between these various points. Between *a* and *b* there can be several hundred degrees of difference."

The following may serve as illustrations of the numerical results obtained.

For *anorthite* from Miyake Idsu, Japan, a crystal remained for a long time unaltered at 1350°; at 1425° it still preserved its cleavage, and 1490° was obtained as the most probable point of the destruction of the crystalline structure. With anorthite of absolute purity, prepared for the purpose, the following values were obtained:

Relation of $\frac{c'}{c}$	Temp. of destruction of the crystal	Capacity in calories of 1 kilo of the fused mineral
7·07	1544°	451·2
7·1	1547°	453·6
7·128	1550°	455·9
7·19	1562°	456·8

For anorthite glass the following points were also obtained:

No. 2, Minimum temperature of the deformation of the glass, 1083°, 1110°.

No. 3, Temperature at which the glass begins to be clouded, 1144°.

No. 3 *bis*, Temperature at which the glass becomes crystalline, labile point, 1210°.

Temperature at which the crystallization has the appearance of being rapid, 1250°.

With *leucite*, at a temperature of 1430° the edges of the crystal were rounded and the faces vitrified though, as a whole, it did not lose its shape. At 1470°, though still preserving its form, it was softened so that it could be easily flattened out by the pincers. At 1500° the glass commenced to form and was complete at 1600°.

For *chrysolite* the point of fusion was too high to allow of being determined accurately but was estimated to be about 50° below that of platinum; 1730° was taken as the probable temperature. *Wollastonite* from Auerbach (monoclinic in crystallization) was liquified at 1366° to a glass which quickly assumed a hexagonal crystalline structure. The artificial hexagonal mineral fused to a fluid, transparent glass at 1515°.

9. *Mineral Resources of the United States. Calendar year 1903.* David T. Day, Chief of Division of Mining and Mineral Resources. 1204 pp. 8vo. Washington, 1904 (U. S. Geological Survey, Charles D. Walcott, Director).—This annual volume of the Geological Survey devoted to the Mineral Resources of the United States, like its predecessors, contains a vast amount of useful and important information. This is made the more valuable from the fact of the admirable promptness with

which it is issued. Much of the matter, further, has already been in the hands of those interested in the form of separately issued pamphlets for the different chapters. The geologist-in-charge states that the report for the calendar year 1904 is already in course of preparation.

10. *Elements of Mineralogy, Crystallography and Blowpipe Analysis;* by ALFRED J. MOSES and CHARLES LATHROP PARSONS. Third enlarged edition. Pp. vii, 444, 8vo. New York, 1904 (D. Van Nostrand Co.).—The new edition of this convenient and useful text-book retains all the good features of the former issues, with some important changes and additions. The crystallography has been rewritten, various changes made in the part devoted to descriptive mineralogy, and the whole brought up to date, so far as statistics and similar matters are concerned. Numerous half-tones from photographs of mineral specimens are introduced; they are in some cases very satisfactory, but share the limitations of such illustrations in general.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Report of S. P. Langley, Secretary of the Smithsonian Institution for the year ending June 30, 1904.* Pp. 1–99. Washington, 1904.—The functions of the Smithsonian Institution are widely varied, including, besides publications and special work of research and exploration, the constantly expanding department of International Exchanges, the National Museum, the National Zoological Park, the Astrophysical Observatory and the Bureau of American Ethnology. This fact gives peculiar interest to the advance report of the Secretary in which the results accomplished for the year are enumerated. Among other points is to be noted the removal of the remains of James Smithson from Genoa, and their deposition in the Smithsonian Institution in the early part of 1904. Another point of interest is the beginning of the new Museum building for which ground was broken June 15, 1904. The new building will be some 551×318 feet and will give a floor area of $9\frac{1}{2}$ acres in its four stories. Some of the results obtained in the Astrophysical Observatory are given on p. 246 of this number.

The Bureau of American Ethnology, W. J. McGee, Acting Director, has recently issued Parts 1 and 2 of the 22d Annual Report. Of these Part 1 (pp. xliii, 320) contains the report of the Director to the Secretary of the Smithsonian Institution; also a paper by Jesse W. Fewkes (195 pp., 70 plates) on Pueblo Ruins; and one by Cyrus Thomas (pp. 197–305, 12 plates) on Mayan Calendar Systems. Part II (372 pp., 9 colored plates) is devoted to a memoir on the Hako, a Pawnee Ceremony by Alice C. Fletcher, assisted by James R. Murie.

2. *Report of the Superintendent of the Coast and Geodetic Survey, showing the Progress of the Work from July 1, 1903 to June 30, 1904.* 774 pp., with numerous plates and four maps.

Washington, 1904 (Department of Commerce and Labor).—The annual volume from the Coast and Geodetic Survey contains the general report of the Superintendent, Mr. O. H. Tittmann, for the year ending June 30, 1904, with special statements from the various assistants and inspectors. A series of nine Appendixes follow, giving the details of operations in the office and field, results of magnetic observations, of work done on telegraphic longitudes, on cotidal lines for the world and other subjects.

From the report by Mr. L. A. Bauer upon the results of the magnetic observations, we have quoted on another page (p. 248). The Superintendent notes the interesting fact of the completion of the determination of the difference of longitude between San Francisco and Manila, and details of the work are given by Assistant Edwin Smith in Appendix 4. It is notable that the finally accepted value of the longitude of the Cathedral dome at Manila differs but 0ˢ·006 from that determined by officers of the U. S. Navy in 1881–82.

3. *The Scottish National Antarctic Expedition.*—The second Antarctic voyage of the "Scotia" has produced some interesting results. The Argentine government has agreed to take over the meteorological and magnetic observatory in the South Orkneys, established by the first Scottish expedition. The newly-discovered part of the Antarctic continent has been named Coatsland, in 74°1′ south, 22°0′ west. Some very rich hauls were made in 1410 fathoms of water in 71°22′ south, 16°34′ west, no less than sixty species of animals being obtained. One of the most interesting results of the exploration is the discovery that soundings made by Ross, and which are represented on practically all maps, are in error. Instead of a sounding of "4000 fathoms, no bottom" a sounding of 2660 fathoms was obtained, and the sea, likewise, is shown to be of much less extent than was supposed. Data were collected at the South Orkneys for a detailed map of Laurie Island; a continuous hourly meteorological record was kept for nine months; botany and geology were investigated, and an extremely rich shallow water fauna was collected. In the South Atlantic a somewhat deeper channel has been demonstrated between the Falkland Islands and the South Orkneys, and farther to the east the ocean maps have been materially changed by the discovery of a large southern extension of the Middle Atlantic ridge to the south of Gough Island.

4. *National Academy of Sciences.*—Vol. V of the Biographical Memoirs has been recently issued; it contains notices of the following gentlemen, former members of the Academy: Joseph Henry, John Edwards Holbrook, Louis François de Pourtalés, Augustus A. Gould, Henry A. Rowland, Theodore Lyman, Matthew Carey Lea, Francis A. Walker, John G. Barnard, James E. Keeler, James Hadley, Henry B. Hill, Sereno Watson, Robert E. Rogers. Each notice is accompanied by a portrait and signature.

5. *The American Museum Journal.*—The January number of this publication is largely devoted to a well illustrated paper by

W. D. Matthew on Fossil Carnivores, Marsupials and small Mammals in the American Museum of Natural History in New York City. Dr. E. O. Hovey also gives an account of the three Cape York meteorites, brought from Greenland by Capt. Peary, the two smaller ones in 1895 and the immense "Ahnighito" in 1897; these are now exhibited at the American Museum. The dimensions of the largest masses are: length, 10 ft. 10 in.; height, 7 ft. 2 in., and thickness, 5 ft. 6 in. The true meteoric nature of these masses is proved by the position in which they were found, as also by the characteristic composition as a nickel-iron alloy and by the octahedral crystalline structure developed by etching.

6. *Reflections suggested by the new Theory of Matter;* by the Right Hon. ARTHUR JAMES BALFOUR, M.P. 24 pp. London and New York, 1904 (Longmans, Green & Co.).—The Presidential address of Mr. Balfour, delivered before the British Association for the Advancement of Science at Cambridge, August 17, 1904, is highly interesting and suggestive, none the less so because the author views the problems of science not as an investigator but in a sense from the outside.

7. *Ideals of Science and Faith*, edited by J. E. HAND (Longmans, Green & Co.).—The first impression that strikes the reviewer in looking over this book is that the ancient feud between science and religion seems to have disappeared. In this volume there is grouped a series of essays by writers in widely diverse fields. The ideals of faith and science are discussed in separate essays, by Sir Oliver Lodge; Professors J. Arthur Thompson, John H. Muirhead, Victor V. Branford, Bertrand Russell, Patrick Geddes; Rev. John Kelman, Rev. Roland Bayne, Rev. Philip Waggett, and Wilfred Ward. Each of these authorities approaches the subject from his own particular view-point. The volume forms delightful reading for such as are interested in broader lines of intellectual development.

8. *Long-range Weather Forecasts;* by E. B. GARRIOTT. Prepared under direction of Willis L. Moore, Chief U. S. Weather Bureau. Washington, 1904 (Weather Bureau, Bulletin No. 322). —This bulletin should be widely read by the public at large, showing as it does how little foundation exists for the general credulity in regard to the possibility of making weather predictions for the distant future. The only suggestion as to probable progress in this direction is contained in the statement, "that advances in the period and accuracy of weather forecasts depend upon a more exact study and understanding of atmospheric pressure over great areas and a determination of the influences, probably solar, that are responsible for normal and abnormal distributions of atmospheric pressure over the earth's surface."

9. *English Medicine in the Anglo-Saxon Times; The Fitz-Patrick Lectures for 1903;* by JOSEPH FRANK PAYNE, M.D. Pp. 162, with sixteen plates. Oxford, 1904 (The Clarendon Press).—This volume contains the lectures, two in number, delivered by Dr. Payne before the Royal College of Physicians of London in June, 1903, somewhat extended by the introduction of

extracts from the works discussed and by other additions. They will be read with much interest by the layman, as well as by the physician, for they give a most interesting account of the early practice of medicine and surgery in England prior to the Norman Conquest, when this practice seemed to be largely based on the use of herbs and on superstition. The accounts given, with extracts, of the Leech Book of Bald and Cid (900–950) and of the Herbarium of Apuleius (1000–1050) deserve careful attention, as well as the representation of favorite plants, often in conventionalized and attractive artistic form.

10. *Studies in General Physiology;* by JACQUES LOEB. Decennial Publications of the University of Chicago, vol. xv. Chicago, 1905. In two parts, I, pp. 1–423; Part II, pp. 425–782. Advance sheets of this work have arrived as the present number is going to press; a notice is necessarily deferred.

11. *Early Stages of Carabidae;* by GEORGE DIMMOCK and FREDERICK KNAB. Springfield, Mass., 1904.—This memoir, illustrated by four plates, forms Bulletin No. 1 of the Springfield Museum of Natural History.

OBITUARY.

ALPHEUS SPRING PACKARD, Professor of Zoology and Geology in Brown University, died at his home in Providence, R. I., February 14, 1905, at the age of nearly sixty-six years.

Professor Packard was a son of the late Professor Alpheus Spring Packard of Bowdoin College, and was born at Brunswick, Me., February 19, 1839. He was graduated from Bowdoin in 1861, and from the Maine Medical School and the Lawrence Scientific School in 1864. At Cambridge he was one of that remarkable group of students—Hyatt, Morse, Packard, Putnam, Scudder, Shaler and Verrill—associated with the elder Agassiz in the early sixties. He served for a time in 1864–5 as Assistant Surgeon in the U. S. Army, but never became a regular practitioner of medicine, his life being devoted to his chosen work in zoology and geology. An enthusiastic field naturalist, collector, and explorer, as well as a very voluminous author who wrote on a remarkably wide range of subjects, he was specially distinguished as an entomologist. He is most widely known, and will probably be longest remembered, for his original work on insects and his several text-books on entomology and zoology. Early in his career he accepted the theory of evolution and later became an ardent neo-Lamarckian. One of his last works was, "Lamarck, the Founder of Evolution, His Life and Work." He was one of the founders of the American Naturalist, for twenty years its chief editor, and a constant contributor to its pages.

Professor Packard was a member of the National Academy of Sciences and of many European societies. Before his appointment at Brown in 1878, he was successively Librarian and Custodian of the Boston Society of Natural History, Director of the Peabody Academy of Science, State Entomologist of Mass., and a member of the U. S. Entomological Commission. S. I. S.

LANTERN SLIDES.

A. Collection of Lantern Slides for Lectures on Petrology,

Arranged by PROFESSOR Dr. K. BUSZ OF MINSTER.

The following collections are now ready:

1. The mode of occurrence of rock-forming minerals, by ordinary light; 50 slides	£3.10.0
2. The mode of occurrence of rock-forming minerals, under crossed nicols; 20 slides	1. 8.0
3. The microstructure of rock-forming minerals; 80 slides	5.12.0
4. The structures of rocks; 36 slides	2.10.0
5. Collection of typical rocks, by ordinary light; 100 slides	7. 0.0
6. " " " " by crossed nicols; 60 slides	4. 5.0

Of Nos. 3, 5 and 6, smaller collections are sold of 50, 75 and 45 slides respectively at £3.10.0, £5.5.0 and £3.3.0.

B. Collections of Lantern Slides for Lectures on Geology and Paleontology,

Arranged by PROFESSOR DR. F. J. P. VON CALKER OF GRONINGEN.

The following are ready:

1. Paleontological Problematica; 30 slides	£2. 2.0
2. Historical Geology (Type-Fossils) (Toula-Collection); 30 slides	2. 2.0
3. Large Phyto-Paleontological collection; 160 slides	11. 5.0
3a. Protozoa (Foraminifera, Radiolaria); 25 slides	1.15.0
4. Pisces; 30 slides	2. 2.0
5. Amphibia; 12 slides	0.17.0
6. Reptilia and aves; 50 slides	3.10.0
7. General Geology; 30 slides	2. 2.0

The slides are sent in paste-board or (the larger collections) in wooden boxes.

Shortly will be ready: *Tectonic Geology, Mammalia, Crystallography.*

The new Collection of 336 Specimens and Slides of Rocks,

According to H. ROSENBUSCH: "Elemente der Gesteinslehre, 2d ed. 1901." Accompanied by a text-book: "*Practical Petrography*," giving a short description of the polarizing microscope and its application, and also of the macroscopical and microscopical features of every specimen of this collection, by Professor Dr. K. Busz of the University of Minster. This collection is intended for the practical use of students and contains typical representatives of all important types of rocks; it is composed of 277 massive rocks; (94 deep-seated rocks, 50 dike rocks, 133 volcanic rocks), 28 sedimentary, and 31 crystalline schists. Out of it two smaller collections of 250 and 165 specimens have been selected. The prices are as follows:

Collection	I.	336 specimens of rocks, 380 Marks.
"	Ia.	336 slides, 420 Marks.
"	II.	250 specimens of rocks, 270 Marks.
"	IIa.	250 slides, 310 Marks.
"	III.	165 specimens of rocks, 170 Marks.
"	IIIa.	165 slides, 205 Marks.

Rock specimens and thin sections of this collection are exhibited at the "St. Louis World's Fair," in the department of the German educational exhibition (Educational Appliances).

Collections of Minerals, Fossils, Meteorites, purchased for cash or exchanged.

The fifth edition of Catalog No. 4, *Petrography*, has just been published (210 pages) and will be sent free of charge on application.

DR. F. KRANTZ,

RHENISH MINERAL OFFICE,

BONN-ON-RHINE, GERMANY.

ESTABLISHED 1833. ESTABLISHED 1833.

ESTABLISHED 1851.

EIMER & AMEND

18th Street and Third Avenue, NEW YORK.

Manufacturers and Importers of

C. P. Chemicals and Chemical Apparatus

Sole Selling Agents for

KUNZITE

(See this Journal, xvi, 264, September, 1903.)

The lately discovered lilac-colored transparent Spodumene from Pala, California.

Nice crystals from $1.00 upwards per specimen.

Kunz-Baskerville Radium Mixtures

CURIE'S RADIUM SALTS

In intensities from 40× activity up to the highest.

Spinthariscopes, Bar.-Platin. Cyanide Screens, etc.

For rapidly and accurately determining Ash and Volatile Ingredients

A few of its advantages:

Uniform, rapid, charring, complete combustion.

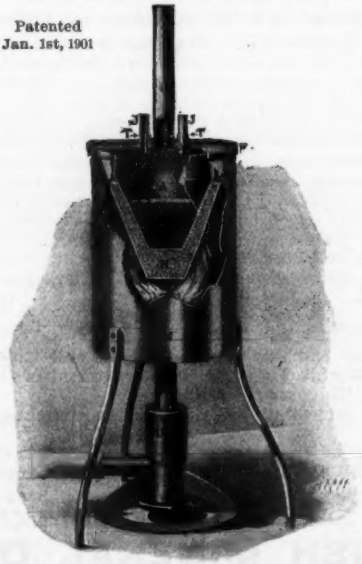
All gaseous products saved.

A sure supply of air.

No washing out of volatile substances necessary.

THE TUCKER APPARATUS

Patented Jan. 1st, 1901



No escape of air.

CO_2 determined without removing ash.

Literature on application.

This is only one of the many forms of Platinum Apparatus made by us. Our "Data Concerning Platinum, Etc.," describes others, and is sent on request.

Let us know if you wish anything made of Platinum. All of our work hammered and guaranteed.

BAKER & CO., 410 R. R. Ave., NEWARK, N. J.

N. Y. OFFICE, 120 LIBERTY STREET

Sole M'frs. of Howard Density Regulator, Shimer Crucible, and Tucker Apparatus.

THE YALE REVIEW

A QUARTERLY JOURNAL FOR THE SCIENTIFIC DISCUSSION OF ECONOMIC, POLITICAL AND SOCIAL QUESTIONS.

Published quarterly on the fifteenth of May, August, November and February. Under the able editorial management of

Professors HENRY W. FARNAM.
EDWARD G. BOURNE,
JOHN C. SCHWAB,
IRVING FISHER,
HENRY C. EMERY,
GUY S. CALLENDER,
CLIVE DAY,
and ALBERT G. KELLER.

"Committed to no party, and to no school, but only to the advancement of sound learning, it aims to present the results of the most scientific and scholarly investigations in history and political science."

Valuable features of the REVIEW are the department of Notes and the Editorial Comment on the current and live topics of the day.

Subscription Rates, $3.00 per year, in advance.

Single numbers, 75 cents.

Sample copies sent free on application. To new subscribers back issues Vol. I to IV sent at $1.00 per volume unbound.

THE TUTTLE, MOREHOUSE & TAYLOR CO.,
NEW HAVEN, CONN.

THE TUTTLE, MOREHOUSE & TAYLOR CO. are also printers of Scientific Works and Works in Foreign Type, in German, Greek, Hebrew, Arabic, Syriac, Sanskrit, Coptic, Ethiopic; printers of The Yale Literary Magazine: Catalogues of Yale University; The American Journal of Science and Arts: Journal of the American Oriental Society; Transactions of the Conn. Academy of Arts and Sciences; Biographies, Genealogies and kindred Works.

REDEMPTIONERS AND INDENTURED SERVANTS

In the Colony and Commonwealth of Pennsylvania, by Dr. KARL F. GEISER, Professor of Political Science in the Iowa State Normal School. In paper covers, $1.00; cloth, $1.50.

THE PHILOSOPHY OF KANT,

In Extracts. Selected by Prof. JOHN WATSON, LL.D., Professor in Queen's University, Kingston, Canada. 194 pp. 8vo, paper cover, 50 cents.

Above works sent postpaid on receipt of price.

PUBLISHED BY

THE TUTTLE, MOREHOUSE & TAYLOR CO.,
NEW HAVEN, CONN.

ROCK AND MINERAL SECTIONS

ON STOCK AND TO ORDER

SET NO. 6.

ILLUSTRATING THE FELDSPARS.

Sixteen sections, $5.25.

ORTHOCLASE parallel basal-, clino-, ortho-pinacoids.
MICROCLINE " " , brachy-pinacoids.
OLIGOCLASE " " " "
LABRADORITE " " " "
ALBITE " " " , macro-pinacoids.
ORTHOCLASE-CARLSBAD twin parallel base.
" BAVENO " " "
" MANEBACH " " clino-pin.
MICRO-PERTHITE.

All orders for this set filled in March will include a section of the rarer feldspar, *anorthoclase*.

Special attention is now being given to the preparation of sections of **Slags** and **Portland Cement Clinkers.**

My business is done by correspondence. Address

W. HAROLD TOMLINSON,
PETROLOGICAL LABORATORY,
44 E. Walnut Lane, - Germantown, Phila., Pa.

The American Naturalist

A Monthly Journal Devoted to the Natural Sciences in Their Widest Sense

Since its foundation in 1867 by four of the pupils of Louis Agassiz, THE AMERICAN NATURALIST has been a representative American magazine of Natural History and has played an important part in the advancement of science in this country.

The journal aims to present to its readers the leading facts and discoveries in the fields of Anthropology, General Biology, Zoölogy, Botany, Paleontology, Geology, and Mineralogy, and the various subdivisions of those subjects.

Annual Subscription, $4.00 net, in advance. Single Copies, 35 Cents. Foreign Subscription, $4.60.

IMPORTANT SCIENTIFIC BOOKS

BERGEN'S
Foundations of Botany
YOUNG'S
Manual of Astronomy
MILLER'S
Laboratory Physics
MILLIKAN'S
Mechanics, Molecular Physics, and Heat
McGREGORY'S
Manual of Qualitative Chemical Analysis

GINN & COMPANY Publishers 29 BEACON STREET BOSTON, MASS.